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Abstract

This paper examines the determinants of expected joint default probabilities of Euro Area country-pairs. Our empirical results suggest that stronger and larger economies with low Debt-to-GDP ratios seem to have lower expected joint probabilities of default. The significance of these effects decreases after the bankruptcy of Lehman Brothers in September 2008, and especially after the outbreak of the sovereign debt crisis in November 2009. In times of crisis, real economy interconnections play a more important role for joint sovereign default risk and more interconnected countries tend to have higher expected joint default risk. Between Lehman Brothers' bankruptcy and the sovereign debt crisis, we find evidence that risk sharing within the Euro Area banking system reduced joint sovereign default risk. We cannot confirm this effect during the sovereign debt crisis. We also document the importance of regional factors on the perceptions regarding the joint probability of default. In line with our expectations, market illiquidity and uncertainty increase the joint likelihood of negative events on the Euro Area sovereign debt market.

JEL classification: G01, G15
Keywords: Sovereign Debt, Financial Distress, Tail Risk

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1 Introduction

The recent financial crisis has drawn significant attention to the problem of sovereign default. Once seen as a riskless haven, the Euro Area (EA) was not immune to this issue. Some Western European countries are dealing nowadays with their overwhelming debt exposures due to bank bailouts and/or excessive government spending. Economic stagnation and reduced government income have further undermined the ability of governments to service their debt. These difficulties have translated into higher sovereign Credit Default Swap (CDS) premia and bond yields required by markets.

The economic problems of Greece, Ireland, Portugal, Belgium, Spain and Italy have sparked the fear of contagion that could threaten the sustainability of the Euro Area. This raises the question of how to measure the degree of vulnerability of sovereigns to joint defaults. In this paper, we derive the *perceived* joint probability of default (JPoD) for EA country-pairs, that is, the market consensus regarding the likelihood of extreme negative events to spread among Euro Area countries. Furthermore, we identify the main determinants of increases in the joint probability of sovereign default.

The paper consists of two main parts. In the first part, we focus on quantifying the probability of joint defaults of EA countries. In our measurement of the joint probability of default, we depart from any ex-post definitions of default and focus on market expectations regarding such events. We recover expected probabilities from the CDS spreads for 13 Euro Area countries between January 2007 and August 2011. In the second part, we investigate the effect of local macroeconomic fundamentals and regional variables on the JPoD for EA country-pairs in our sample. We also examine how these effects change between different episodes of the financial crisis.

Our JPoD results reveal considerable heterogeneity in the levels of perceived joint default risk across the country-pairs that we investigate. However, two events seem to play an important role for the overall JPoD dynamics: Lehman Brothers' filing for bankruptcy in September 2008 and the Greek government's announcement of its fiscal problems in early November 2009. The subsequent empirical analysis suggests that *stronger* and *larger* economies with *low* Debt-to-GDP seem to have lower perceived joint probability of default. Furthermore, we find evidence for changes in the magnitude and significance of these effects across different subperiods, before and after the aforementioned major debt events. Real economy interconnections also seem to play a significant role in forming the market perceptions on sovereign default risk, as more interconnected countries tend to have higher JPoD, especially in the two subperiods after Lehman Brother's collapse. In the interim period between Lehman's bankruptcy and the sovereign debt crisis, we find that risk sharing within the EA banking system reduced joint sovereign default risk. The latter effect is not present during the sovereign debt crisis. Moreover, EA illiquidity and uncertainty seem to be important determinants of the JPoD across almost all subperiods.

Most recent studies on sovereign distress analyze the *linear* dependence between countries, instead of focusing on tail risk measures. Longstaff et al. (2011) conclude that sovereign debt returns are more correlated than equity returns, based on a sample of 26 countries. Pan and Singleton (2008) study the linear dependence of five-year CDS contracts on sovereign debt of Korea, Turkey and Mexico and find a high level of co-movement between these instruments. Moreover, Reinhart and Rogoff (2011) find that linear dependence during extreme events in sovereign markets seems to be as strong as in normal times.

In contrast to those previous studies, we argue that the event of an advanced economy defaulting should be considered a tail event. A well-known fact in the economics and statistics literature is that linear dependence measures like the correlation coefficient fail to capture well the dependence structure in the tail of the joint distribution.[1] Therefore, they are inadequate for investigating the current sovereign debt crisis. To overcome this deficiency, we employ a procedure that models the tail behavior of sovereign assets, compatible with the literature on contagion. Our approach is based on the Consistent Information Multivariate Density Optimizing Methodology (CIMDO) developed by Segoviano (2006). This methodology has recently been used by Goodhart and Segoviano (2009) to construct banking stability measures. Under this framework, we view the Euro Area as a joint distribution of its individual constituents. To account for the fat tails characteristic of financial markets, the CIMDO approach adjusts the tail regions of this distribution with market-derived information about their probability mass.

The benefit of this methodology is that it allows us to model nonlinearities in the multivariate distress-dependence structure, making it more flexible in capturing joint extremes compared to the usual Pearson's correlation coefficient. Furthermore, the CIMDO approach is specifically designed to make efficient use of a limited amount of publicly available time-varying country-specific information. Due to the dynamic updating of the joint density with new empirical information, the underlying dependence structure of the CIMDO distribution is intrinsically time-varying. With the help of this approach, we derive the joint distribution of EA sovereign assets. Focusing on the tails of this distribution yields our sovereign JPoD measure.

Sovereign defaults, however rare, have serious welfare costs not only for the parties in-

[1] See Embrechts et al. (1999) for several examples of improper inference using the correlation coefficient. In the case of the bond markets discussed in this paper, interpreting a high correlation coefficient as an indicator for high joint probability of default would be an example of erroneous inference.

volved in the debt contract, but also for third parties if the default risk spreads. On one side, we have the loss of reputation and limited future access to international debt markets of the defaulted sovereign (see Panizza et al., 2009). On the other, sovereign defaults have direct negative effects on domestic firms and foreign creditors (see Arteta and Hale, 2008). Thus, sovereign default issues could easily transmit throughout the Euro Area's financial system due to the complex links between EA sovereigns, EA banks and between EA sovereigns and banks. Apart from financial channels, contagion could also spread through real economy channels, because of the strong economic links within the common currency area.

After deriving investors' perceptions about joint sovereign default, we undertake an empirical analysis to single out which factors are of importance to international investors when analyzing contagion risks. Such an analysis has strong implications for policymakers and regulators alike for a number of reasons. First, policymakers are interested in the level of systemic risk, that is the risk of a particular negative event to spread throughout the financial system. In this respect, our measure of joint default risk provides an estimate of the vulnerability of the Euro Area to a sovereign default event. Other things equal, the higher the (unconditional) joint default probability, the higher the probability of an entity to default is, given that another entity defaults. Second, analyzing market expectations can provide important insights and recommendations to policymakers when deciding on what measures should be undertaken to defuse contagion risks. In this context, it is essential to know whether investors perceive the real economy or financial interconnections between EA countries to be of major importance in default spreading across the currency union. Third, as the main sources for public financing in the EA are the international financial markets, it is crucial to know what influences investors' decisions when evaluating default risk, since this is a major component in bond pricing, apart from the time value of money and liquidity risk. Recent developments on the CDS and bond markets show that investors do not only price in individual sovereign characteristics and global risk factors (see Pan and Singleton, 2008; Hilscher and Nosbusch, 2010; Longstaff et al., 2011), but also seem to take into account the interdependence among countries. This paper tries to quantify the influence of the latter.

Our contribution to the existing literature is three-fold. Our main contribution is that we complement and extend the literature on identification of determinants of sovereign default risk, which focuses solely on *individual* default probabilities. To the best of our knowledge, we are the first to analyze determinants of *joint* sovereign default risk. Second, we are among the first to view a set of countries as a multivariate joint distribution and to examine their joint tail behavior. The few other studies with such a setup are Gray et al. (2007), Goodhart and Segoviano (2009) and Zhang et al. (2011). None of those previous studies, however, goes beyond descriptive analysis of the probability results. Third, we extend the CIMDO approach at the methodological level, departing from the independence assumption in previous CIMDO studies that significantly understate the joint distress risk between sovereigns and banks (see Segoviano, 2006; Goodhart and Segoviano, 2009; Pena and Rodriguez Moreno, 2012). In addition, we provide a series of robustness checks for the CIMDO methodology that aim at shedding more light on the benefits and limitations of this approach.

The remainder of the paper is organized as follows. In section 2, we present our methodology and provide various robustness checks. Section 3 outlines our JPoD estimation procedure and presents selected results. Section 4 describes the results of our empirical analysis regarding the determinants of perceived sovereign JPoD. Section 5 concludes.

2 Methodology

2.1 CIMDO vs Structural Credit Models

We base our methodology for recovering the Joint Probability of Default on the CIMDO approach developed by Segoviano (2006). This approach complements the structural credit model of Merton (1974). In the original model, the company defaults if the value of its log-normally distributed assets is less than the promised debt repayment at the time of maturity. An extension of the model, proposed by Black and Cox (1976), introduces a default threshold that is set exogenously. Default occurs whenever the assets of the company fall below this threshold. A shift of the default threshold can accommodate any time-varying estimates of the probability mass in the tail of the distribution.

Segoviano (2006) uses a similar threshold set-up as in Black and Cox (1976), but approaches modeling of fat-tails in a different manner. In his model, the probability mass beyond a predefined and *fixed* threshold is allowed to change in line with empirical information regarding defaults. This is achieved by shifting mass from the center of a conceptual *prior* distribution (standard Gaussian distribution in Segoviano, 2006) to the region beyond the fixed threshold in a way that fits empirically observed default probabilities. The result is a non-standard fat-tailed *posterior* distribution. Furthermore, in a multivariate setting, the CIMDO approach allows us to recover *joint* probabilities of default from empirical data on *individual* entities.

Another attractive feature of the CIMDO approach is that it has relatively straightforward applicability in the context of sovereign defaults. The main issue in assessing the default probability of a sovereign is the lack of timely information regarding the value of sovereign assets. Only some sovereign assets have a directly observable market value. Gapen et al. (2008) provide details on the degree of observability of items on country's balance sheet and develop a method to quantify the market value of these assets. The authors calculate the probabilities of default based on the observable value of sovereign debt and the alleged value of sovereign assets.[2] The CIMDO approach, in comparison, lets us recover joint probabilities of default without taking any stance on the observability of sovereign assets. This agnostic view allows us to extend the definition of sovereign assets to incorporate not only *tangible* assets (e.g. tax revenue), but also *intangible* assets, like the "willingness to repay" that plays a central role in sovereign default literature (see e.g. Manasse and Roubini, 2009; and Reinhart and Rogoff, 2009).

The CIMDO approach is classified in the category of market-based models in the financial stability literature, as summarized by Gray (2011).[3] Alternatively, Gramlich and Oet (2011) divide financial stability models in two broad groups: functional approaches/network models (see Allen and Gale, 2000; Furfine, 2003; Caballero and Simsek, 2009) and statistical models (see Lehar, 2005; Acharya et al., 2009; Adrian and Brunnermeier, 2011), listing the CIMDO model in the latter group. A common thread among most of these models is that they investigate primarily the stability of the banking system, neglecting the sovereign dimension of the financial system. In the next subsection, we provide more details on how the CIMDO approach can be used to recover joint probabilities of default for sovereign entities.

2.2 Recovering the Joint Probability of Default

CIMDO is centered on the concept of cross-entropy, introduced by Kullback (1959). It consists in minimizing the cross-entropy objective function that links the prior and posterior distributions of logarithmic assets, mentioned above. The minimization problem is subject to a set of constraints on the posterior that reflect empirical information about the default frequency of the individual entities under investigation (sovereigns in our case). This technique allows us to adjust our prior guess about the form of the joint distribution function of logarithmic assets. We begin our analysis by assuming a bivariate normal density function as our prior, in line with the literature on structural credit models.[4] Log-assets are assumed to be correlated between two sovereigns. The solution to the minimization problem is a posterior density, which mirrors the behavior of the prior in particular areas of the distribution. However, due to the empirical adjustment, the posterior function may assign a higher or lower probability mass to its tail region, compared to the corresponding region of the prior.

[2]The paper builds on the work of Gray et al. (2007) and uses a modified version of the original structural credit model of Merton (1974).

[3]The other possibilities being balance sheet and market equity based models, as well as interactions between those three groups.

[4]In this paper we concentrate on bivariate default probabilities. For a multivariate extension, please refer to Radev (2012).

We start by considering two sovereign debt issuers, say countries X and Y, with their logarithmic assets represented by two random variables, x and y. The cross-entropy objective function is then:

$$\chi(p,q) = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} p(x,y)\ln\left[\frac{p(x,y)}{q(x,y)}\right]dxdy \tag{1}$$

where $p(x,y)$, $q(x,y) \in \mathbb{R}^2$ are the posterior and the prior bivariate distributions respectively.[5] The function $\chi(p,q)$ characterizes the probabilistic divergence between the two distributions. Our objective is to minimize the entropic distance without postulating anything else about the posterior distribution, apart from the information contained in empirical data. This information is synthesized in the consistency constraints that have to be fulfilled by the posterior function:

$$\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} p(x,y)\mathbf{I}_{[x_d^x,\infty)}dxdy = PoD_t^x \tag{2}$$

and

$$\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} p(x,y)\mathbf{I}_{[x_d^y,\infty)}dydx = PoD_t^y \tag{3}$$

with PoD_t^x and PoD_t^y representing the market perceptions about the individual probabilities of default of countries X and Y, recovered from CDS data.[6] $\mathbf{I}_{[x_d^x,\infty)}$ and $\mathbf{I}_{[x_d^y,\infty)}$ are binary functions employing the country-specific default thresholds x_d^x and x_d^y for each sovereign. Whenever variables x and y are above the thresholds, the binary function takes the value of one, and zero otherwise. The country-specific default threshold is set exogenously and is defined as the inverse of the cumulative density function of the univariate normal distribution at the average country PoD level, where the country averages are computed for the entire period of investigation.

The consistency constraints (2) and (3) imply that in the region of default, the posterior distribution will have marginal probability mass at the same level as the expected probabilities of default for each sovereign separately. In other words, the shape of the multivariate distribution of log-assets will be updated at each point in time, such that its default region

[5] Given our initial assumption of bivariate normality, $q(x,y)$ has the following form: $q(x,y) = \frac{1}{2\pi\sqrt{1-\rho^2}}\exp\left(-\frac{1}{2(1-\rho^2)}\left[x^2+y^2-2\rho xy\right]\right)$.

[6] We discuss the estimation of these probabilities in more detail later in the text.

is consistent with the market consensus about each sovereign's expected probability of default. To simplify the exposition, we set the region of default for each obligor in the upper part of the distribution. The results are equivalent when we set the region of default in the lower part of the distribution due the symmetricity of the normal distribution.[7] To fulfill the requirements of a density function, $p(x, y)$ needs to satisfy the non-negativity constraint $p(x, y) \geq 0$, as well as the additivity constraint $\int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} p(x, y)dxdy = 1$.

Including this set of constraints in our specification, we come up with the following function to be minimized:

$$
\begin{aligned}
\mathcal{L}(p, q) = & \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} p(x, y) \ln \left[\frac{p(x, y)}{q(x, y)} \right] dxdy \\
& + \lambda_1 \left[\int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} p(x, y)dxdy - 1 \right] \\
& + \lambda_2 \left[\int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} p(x, y)\mathbf{I}_{[x_d^x, \infty)} dxdy - PoD_t^x \right] \\
& + \lambda_3 \left[\int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} p(x, y)\mathbf{I}_{[x_d^y, \infty)} dydx - PoD_t^y \right]
\end{aligned} \tag{4}
$$

where λ_1, λ_2, and λ_3 are the Lagrange multipliers of the additivity and the two consistency constraints, respectively. The optimal solution for the posterior density is then of the form:

$$
p^*(x, y) = q(x, y)exp \left\{ - \left[1 + \lambda_1 + \left(\lambda_2 \mathbf{I}_{[x_d^x, \infty)} \right) + \left(\lambda_3 \mathbf{I}_{[x_d^y, \infty)} \right) \right] \right\} \tag{5}
$$

As can be seen from the solution, the only information that we need to derive the posterior distribution from the prior guess is the prior distribution itself, the default thresholds and the optimal sovereign Lagrange multipliers, derived for the particular set of default thresholds and individual probabilities. Furthermore, our posterior distribution will diverge from its prior whenever one or both empirical marginal probabilities differ from the mass that the *prior* distribution assigns beyond the respective thresholds (that is, if any of the Lagrange multipliers λ_2 and λ_3, or both, are different from zero). If no adjustment of the prior is prescribed by empirical data (both λ_2 and λ_3 are equal to zero), the additivity constraint

[7]Please refer to Figure 1 in Segoviano (2006) for further considerations on this matter.

multiplier λ_1 will automatically be set to -1.[8]

Having estimated the posterior bivariate density function, we can employ this result in modeling joint defaults. We define our Joint Probability of Default measure as follows:

$$JPoD_{x,y} = \int_{x_d^x}^{+\infty} \int_{x_d^y}^{+\infty} p(x,y)dxdy \tag{6}$$

Hence, we focus on the region of the posterior distribution $p(x, y)$, where *both* sovereign debt issuers are expected to default (x and y are above their thresholds). In Section 3, we recover the JPoD for 13 EA sovereigns and in Section 4 we undertake an empirical analysis aiming at identifying the determinants of perceived joint default risk in the Euro Area.

2.3 Alternative Specifications of the Prior Density

Segoviano (2006) presents detailed robustness checks for the cases when there are errors in the optimal density or perturbations in the prior distribution. Moreover, CIMDO densities seem to outperform other most commonly used parametric distributions under the Probability Integral Transformation Criterion, developed by Diebold et al. (1998).

One issue that is left without attention in Segoviano (2006) is the sensitivity of the CIMDO posterior distribution to changes in the correlation structure. In Figure 1, we show that when a joint normal distribution is assumed as a prior, $q(x, y)$, the correlation coefficient will play a significant role in assigning the probability mass to the different regions of the posterior distribution. As Figure 1 shows, assuming a correlation higher than zero leads to shifting more probability mass toward the tail of the posterior distribution. Hence, if log-assets are positively correlated, CIMDO would assign a higher probability to joint defaults. Since imposing independence between sovereigns seems unreasonable in the context of the contagion patterns observed in the Euro Area CDS market, especially after the end of 2009, we allow for a flexible correlation structure, estimated from empirical data.[9]

We consider one additional robustness check with respect to the assumed shape of the prior density. Figure 2 explores the differences in JPoD when we use a bivariate t-distribution as our prior, opposing to the case of a bivariate normal distribution.[10] In the case of the t-distribution, we consider different degrees of freedom, ν. When compared to the JPoD

[8] If no adjustment is needed, the posterior distribution is equivalent to the prior. The latter satisfies the conditions for a density function by construction.

[9] More details with regard to the correlation estimation are provided in Section 3.2. Please refer to Radev (2012) for a detailed discussion on how independence between entities transfers to the CIMDO posterior distribution.

[10] Positive correlation between logarithmic assets is assumed in both cases.

recovered by updating the bivariate normal prior (dotted line), the t-distribution yields higher joint probabilities of default for all degrees of freedom. This should come as no surprise given that the t-distribution is known to have fatter tails for modest degrees of freedom, and converges to the normal distribution in the limit. Since the change of JPoD behaves in a predictable manner, we maintain the original suggestion of Segoviano (2006) and use the bivariate normal density function as a prior distribution.

3 Estimating the Joint Probability of Default

In this section, we estimate the JPoD for our sample. We start by describing the estimation of marginal probabilities of default, followed by the default thresholds and the choice of correlation structure. We conclude with a descriptive analysis of our results.

3.1 Marginal Probabilities of Default

We recover individual default probabilities from CDS data by implementing a standard cumulative survival probability model, based on Hull and White (2000). This procedure assumes a piecewise flat hazard rate term structure and uses the shortest maturity CDS data to calculate initial survival probabilities. Those values later serve to recover the subsequent probabilities for higher maturities. Because the recovered term structure of hazard rates is arbitrage-free, that is, it generates rates required by the model to fit the market, we arrive at risk-neutral probabilities of default.

This procedure uses as inputs data on CDS and bond yields across different maturities, as well as a recovery rate for the case when defaults occur. We rely on CDS data because sovereign defaults are relatively rare events and it is difficult to arrive at meaningful ex-post default frequencies even for countries at the brink of insolvency. Moreover, by using sovereign CDS spreads we can analyze market expectations about *individual* default risk and transforms them into perceptions regarding *joint* sovereign default risk.

We use daily CDS spreads with 1-year, 2-year, 3-year, 4-year and 5-year maturities, as well as 3-month, 6-month, 9-month, 1-year, 2-year, 3-year, 4-year and 5-year AAA EA sovereign bond yields. The latter serve as refinancing rates for our bootstrapping procedure.[11] The data on CDS spreads comes from Datastream and the bond yields are constructed based on the ECB index of AAA-rated sovereign bonds of the Euro Area countries, available in SDW

[11]The same procedure was implemented using German government bond yields as a risk-free benchmark, but this would have precluded using Germany in our later analysis. The resulting probabilities are virtually the same.

(ECB Statistical Data Warehouse). The countries considered in our analysis are Austria, Belgium, Cyprus, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Slovakia, Slovenia and Spain.[12] We use daily observations between January 1, 2007 and August 31, 2011. This sums up to a total of 1218 observations for each country, excluding holidays and weekends.

We present summary statistics for the whole sample in Table 1. Greece and Portugal have the highest CDS spreads in our sample. Apart from these two countries, average CDS spreads of Ireland, Italy and Spain are above 100 basis points. Given the relatively high price of protection against the default of each of these five countries, we label them as troubled economies (GIIPS[13]). The evolution of the CDS spreads is mirrored in the levels of estimated marginal probabilities of default. The GIIPS have higher expected probabilities of default. These probabilities are cumulative 5-year PoD recovered using the bootstrapping procedure described earlier.

3.2 Recovery Rate, Default Threshold and Correlation Structure

Figure 3 presents the impact of changes in the recovery rate on the probabilities of default for Greece, generated using the bootstrapping procedure on a 5-year horizon. The probability of default rises monotonically with higher recovery rates.[14] In what follows, we rely on the sovereign debt literature and assume uniformly a 70% recovery rate for government bonds. This value stems from the findings in Sturzenegger and Zettelmeyer (2005) with regard to sovereign debt haircuts, and is significantly higher than the 40% average recovery rate usually assumed for debt instruments issued by commercial banks.

As explained in Section 2.2, the default threshold is one of the central parameters of the CIMDO methodology. We define the country-specific default threshold as the inverse of the cumulative density function of the normal distribution at the sample average PoD of each sovereign. As reported on the last line of Table 1, the probability mass beyond the threshold for the troubled economies is greater than for countries considered distress-free.

Our robustness checks in Section 2.3 showed that the correlation coefficient is another parameter that influences the form of our prior and posterior distribution functions. For each bivariate couple, we calculate the sample correlation between changes of the respective CDS

[12] For Ireland, we could not retrieve any CDS spreads for contracts maturing in 2 or 4 years for 2007. For this period, we recover the PoD only using the remaining available maturities. This should not change dramatically our results, however, since the CDS spreads for the rest of the maturities for Ireland in 2007 exhibit almost no volatility and have relatively low levels.

[13] GIIPS is an abbreviation of Greece, Ireland, Italy, Portugal and Spain that we will use throughout the text.

[14] A high recovery rate implies that the creditors would suffer minimum losses.

premia and use these estimates to construct our prior in each time period. This is a model-free approach, which we use to proxy for the correlation between the unobservable assets of the sovereigns. An alternative way to measure correlation between these assets would be to estimate their value as described in Gapen et al. (2008) and compute the correlation between the estimated log-asset values. The signs and magnitude of these correlation coefficients are unlikely to be different from ours, as the measures recovered by Gapen et al. (2008) are shown to be highly correlated with the CDS premia of the respective countries. We report the correlation coefficients used in our analysis in Table 2. We can notice that the correlation coefficients are higher for couples that include only troubled economies.

3.3 Country-Pair Results

In this subsection, we examine the country-pair results underlying the extreme cases of sovereign joint probability of default, as defined in Equation 6, and some of their conditional counterparts.[15] Figure 4 stresses how our final results with regard to the joint probabilities of default are affected by the choice of the correlation coefficient assumed for the theoretical prior. It presents the results for differences in the JPoD in cases of zero and nonzero correlation for both low and high correlation couples. For each of the couples, we construct the differences by subtracting the zero-correlation JPoD measure from the correlation-adjusted JPoD. The country-pairs considered in this plot are as follows: Germany and Greece ($\rho = .34$); Portugal and Spain ($\rho = .76$); Greece and Portugal ($\rho = .69$). A nonlinear time path of the difference between the two joint probabilities of default is characteristic for all couples. As expected, a higher correlation coefficient widens the gap. We argue that it is highly unlikely that the assets of the sovereigns in a currency area are uncorrelated, mainly due to the economic ties between the countries. Therefore, in the reminder of this section, we present only results for the joint and conditional probabilities of default when the correlation coefficient is not restricted to zero.

We summarize our results in Figure 5. For each day in our sample, we calculate the cross-sectional average, minimum and maximum levels of the JPoD. We plot our results along the timeline and distinguish between three subperiods. Our first cut-off date is September 15, 2008. Lehman Brothers filled for bankruptcy on the weekend prior to this date. We select as our second cut-off date November 5, 2009. On this date, the Greek government announced a budget deficit of 12.7 percent of GDP, well above the threshold stipulated by the Maastricht criterion. The announcement was the main driver of the downgrades of Greek debt that followed thereafter. Prior to September 2008, maximum JPoD barely reaches 3% and the

[15] We investigate all bivariate combinations between the 13 countries in our sample, resulting in 78 couples.

average JPoD is indistinguishable from zero. Afterwards, the levels rise and exhibit sharp changes along the timeline.

Figure 6 presents the results of our JPoD estimation for several country-pairs under investigation.[16] These plots depict the joint probability of default of the respective couple, juxtaposed to the 5-year conditional probabilities of default for each country, where we condition on the event of the other country defaulting. As we can notice from the first plot of Figure 6, after a long period of virtually zero joint probability of default (dotted line), Austria (solid line) and Germany (dashed line) experience an increase of the 5-year conditional probability of default after the collapse of Lehman Brothers in September 2008. Austria is perceived by investors as being the riskier country, with conditional probability of default peaking at around 70% in the first quarter of 2009. This peak might be a reflection of the market uncertainty regarding the Austrian government's solvency, as it carried out several bank bailouts at that time. Apart from this period, the joint probability of default is rarely above zero, implying that investors expect that it is very unlikely that both countries are going to default simultaneously.

Germany (solid line) and Greece (dashed line), depicted in the second subplot, show a quite different picture for the probabilities of default, reflecting the differences in the perceived riskiness of both economies. We still observe an upward trend in the joint probability of default in last quarter of 2008, however this trend vanishes by the end of the first quarter of 2009. The high levels of conditional probability of default for Greece may be due to the dependence of Greece on bailout funds from the Euro Area states, especially from Germany, implying that extreme negative events in Germany would have huge repercussions on Greece. Indeed, the conditional probability of default for Greece reaches almost one by the end of our sample.

Ireland (dashed line) and Greece (solid line), shown on the third subplot, exhibit a more volatile behavior after the third quarter of 2009. As small open economies, these countries were more susceptible to the dire outlooks of the world economy in 2009. After the outbreak of the Greek sovereign debt crisis, we observe a relatively steady upward trend in both the conditional probability of default for Greece and the joint probability of default (dotted line), which might be attributed to the shift in risk aversion of international investors in that period (ECB, 2010). The joint probability of default peeks at above 60% at the end of the analyzed period. It is interesting to notice that throughout 2009, the 5-year conditional probability of default of Ireland is higher than that of Greece, but the trend reverses in the last months of that year.

[16] The remaining plots are available upon request.

In summary, we confirm that empirical correlation plays a vital role for the level of joint default risk and for capturing contagion on the sovereign debt market. Furthermore, although there is heterogeneity in the level of perceived sovereign joint default risk across country-pairs, two events seem to play an important role for the overall JPoD dynamics: Lehman Brothers' bankruptcy and the Greek government's announcement in early November 2009. Taking these two observations into consideration, the remainder of the paper aims to: first, determine the main driving factors of the correlation adjusted JPoD; and second, trace the influence of these factors during the pre-Lehman period, the interim period between Lehman's collapse and the outbreak of the sovereign debt crisis, and the period thereafter.

4 Empirical Analysis: Determinants of Joint Probability of Default in the Euro Area

Are large economies safe from joint default? Are countries that trade extensively among each other more likely to fail on their obligations together? Do financial interconnections increase or alleviate joint default risk? Do global uncertainty and illiquidity affect joint default risk? In this section, we investigate the effects on the joint probability of default of various factors, considered in the sovereign distress literature to be determinants of default risk.

4.1 Empirical Model

The starting point of our analysis is to recognize that joint default should depend on the economic conditions and the specific characteristics of a country-pair. Therefore, we construct our explanatory variables such that they could represent common features between the constituents of a country-pair. Furthermore, when possible, we give priority to publicly available bilateral variables that by definition describe interconnectedness and joint behavior of the countries in a couple (i.e. bilateral trade, or claims of banks). Our bivariate JPoD measure is particularly suitable for accommodating such bilateral factors in a regression analysis. In addition, our analysis should take into account the fact that the joint default patterns of a specific country-pair might be influenced not only by characteristics pertaining to the couple itself, but also by regional Euro Area factors.

Therefore, we are interested in the following linear regression model:

$$JPoD_{ijt} = \alpha + \beta \cdot LocalFactors_{ijt} + \gamma \cdot X_t + \epsilon_{ijt}, \tag{7}$$

where $JPoD_{ijt}$ is the logit transformation of joint probability of default for a given country-pair, involving countries i and j, $LocalFactors_{ijt}$ is a vector of variables, relevant for the particular couple, and X_t is a vector of Euro Area-related controls. The main factors of interest are the couple-related variables.

Unreported robustness checks showed that most of our variables are non-stationary, which would yield inconsistent results when running regressions in levels. To tackle this issue, as well as to account for possible omitted time-invariant couple variables, we run our model in first differences on monthly basis. To account for additional couple-related time trends, we include couple fixed effects in all our regressions. We do not include time fixed effects, as they will strip our results off the cross-sectional commonality that we are trying to explain. However, we take into account time fixed effects in levels, by including regional controls in our regressions, X_t. In addition, all couples that involve a particular country are related.[17] To account for this cross-sectional correlation across country-pairs, we calculate heteroscedasticity-robust standard errors, clustered by country. This correction yields higher standard errors, thereby leading to more conservative p-values.

In the next subsection, we outline the set of hypothesis that we would like to test in our regression analysis.

4.2 Hypotheses

The ability of a sovereign to service its debt is a function of the state of its economy. Transferring this intuition to a bivariate setting, one would expect that the better the general economic conditions in a country-pair, the lower the sovereign joint likelihood of distress is. Thus, our first hypothesis reads:

Hypothesis 1. *Stronger economies have lower probability of joint default.*

A crisis could affect both small and big countries alike, but one would expect that the smaller sovereigns would have limited possibilities to address the adverse effects of financial or economic crises on their ability to service their debt. Hence, we formulate our Hypothesis 2 as follows:

Hypothesis 2. *Larger economies have lower probability of joint default.*

An overarching theme during the sovereign debt crisis is the huge amount of public debt that the Euro Area governments have amassed either due to imprudent spending or due to stimulus packages and bailout schemes. We would like to formally test whether international investors take into account the Debt-to-GDP ratios in forming their expectations regarding sovereign default. Therefore, our Hypothesis 3 postulates:

[17] E.g. the couple Germany-Greece is correlated with the couple Greece-Spain by construction.

Hypothesis 3. *Sovereigns with higher public-debt-to-GDP ratio have higher joint probability of default.*

As the common currency facilitates trade between Euro Area countries, their real economies are heavily interlinked. In periods of upturn, trade connections boosts economic growth, but in case of a negative real economy shock to one sovereign, the recession might easily spread to its trading partners. To test whether sovereign default risk might transmit via real economy channels, we introduce Hypothesis 4:

Hypothesis 4. *Real economy interlinkages increase the probability of joint default.*

A shock due to sovereign default could easily transmit to and within the banking system, because of the extensive mutual business relations of Euro Area banks. This could further put a strain on other sovereigns to borrow funds in order to prevent a banking crisis. On the other hand, the extensive network of interactions between Euro Area banks might result in risk sharing that could mitigate the risk of a banking turmoil. Thus, a major question among regulators is whether the tight banking system interlinkages between Euro Area countries would exacerbate or defuse sovereign default risk. To provide an empirical test of these effects, we formulate the following Hypothesis 5:

Hypothesis 5. *Banking interlinkages decrease the probability of joint sovereign default.*

To summarize, we expect that (i) the stronger and (ii) the larger the economy of a country-pair, the lower the perceived joint default risk is. Conversely, (iii) the more indebted the governments and (iv) the higher the real economy interdependence within a couple, the higher the perceived joint default risk is. Furthermore, (v) banking interconnections tend to decrease the perceived joint default risk.

4.3 Data

Our main data source for daily CDS spreads, stock index quotes, exchange rates, implied volatility indices, as well as for EURIBOR and EONIA data is the Thomson Reuters Datastream. For daily data on Euro Area government bond yields, we use ECB's Statistical Data Warehouse. We collect monthly reserves data from IMF's World Economic Outlook Database, as well as quarterly Gross Domestic Product (GDP) and bilateral banking claims data from Bloomberg and the Bank of International Settlements (BIS), respectively. For yearly bilateral trade and government debt data, we use respectively the Organisation for Economic Co-operation and Development's Bilateral Trade (OECD BTDIxE) and the the World Bank's World Development Indicators (WB WDI) databases.

We run our regressions on a monthly basis. To accommodate the data of different frequencies, we apply cubic spline interpolation to transform yearly and quarterly data to monthly frequency. For the daily data, in our first differences regressions we use the last data point available for the particular month. As the trade data are available in US Dollars only, we convert the values to Euros, using the EUR/USD exchange rate of the last day of each month. Our sample period spans from January 2007 to August 2011, resulting in 56 monthly observation.

4.4 Variables

This subsection provides detailed information with regard to the construction of the variables in our regression analysis and presents descriptive statistics of the dataset. Table 3 provides a short description of our variables along with their sources.

4.4.1 Local Variables

Our set of local variables aims at answering the question what common couple characteristics affect the expected likelihood of joint negative events on the sovereign debt market. For this reason, we gather both market and macroeconomic data which we use to proxy for a number of cross-country relationships. Whenever bilateral variables are not available, we construct couple-specific variables based on country-specific data.

The first three variables refer to the economic conditions within a pair and could be viewed as proxies for economic strength, and hence provide a test for Hypothesis 1.

Business climate. Our first local variable represents the influence of economic activity in the respective couple on joint default probability. As a proxy, we construct a portfolio of the average 6-month returns of the main stock market indices of each country, weighted by the respective GDP level in 2006. For easier interpretation, we multiply the results by 100. Our prediction is that improving economic prospects, signaled by a positive portfolio weighted return, should decrease the probability of joint default. The influence of local stock market returns on the country's credit spread has been considered for the univariate case in Longstaff et al. (2011). In line with our expectation, Longstaff et al. (2011) find that positive local stock returns decrease the spread in almost all the countries in their sample, thereby lowering the probability of sovereign default. The coefficient is significant for 11 of their 26 country regressions.

Local Uncertainty. To account for local uncertainty, we use the average country stock market volatility. Volatility for each country is constructed using a rolling window of 6 months and multiplied by 100. High volatility on the stock market reflects uncertainty about the prospects of the economy to generate profitable opportunities. This uncertainty could be thus viewed as uncertainty about the flow of government income that should cover public services and, most importantly in our case - sovereign debt interest payments. Hence, in line with Hypothesis 1, we expect a positive relationship between average stock market volatility and the perceived joint probability of default. To the best of our knowledge, this channel has not be studied so far in the sovereign debt literature. However, there are a number of studies that look at the response of corporate CDS spreads to increasing stock market volatility. Alexander and Kaeck (2008) find that stock market volatility has a predominant influence on changes in CDS spreads during a crisis period.

Liquidity buffer. An additional variable of interest is the total reserve assets of the respective countries, defined as the logarithm of the sum of the sovereign reserve assets. Raising the amount of total reserves should serve as insurance against unfavorable government income shocks. This should, other things equal, decrease the probability of both sovereigns defaulting on their debt simultaneously. We consider this variable to reflect the joint resilience potential of sovereigns, hence as a test for Hypothesis 1. We use monthly reserves excluding gold, since the high volatility in the gold market might not be properly and timely reflected in the central bank's balance sheet. Therefore, reserves including gold might not reflect the actual sovereigns' instantly disposable resources. However, our results are robust when reserves including gold are considered instead.

There is mixed evidence in the empirical literature on the importance of this factor at the individual country level. Longstaff et al. (2011) test the influence of reserves on sovereign CDS spreads and find mainly insignificant results. Moreover, the significant coefficients for some countries in their study appear to be with contradicting signs. Remolona et al. (2008) use a dynamic panel data model and show that higher reserves significantly reduce their measure of sovereign risk. Hilscher and Nosbusch (2010) document a similar effect using a larger panel of countries.

Size. The size of the countries has direct implications with regard to the joint probability of default, as larger sovereigns might have lower individual probability of default, decreasing the overall JPoD, other things equal. Indeed, as noted by Pan and Singleton (2008), sovereign CDS traders consider the size of a country to be an important determinant of economic recovery. Hence, decreasing default rates should be characteristic for expanding economies. Furthermore, our trade- and banking-related variables could be affected by the phase of economic cycle, in which a particular couple is currently in. To control for the size and the business cycle, we include the logarithm of the sum of the GDP levels of the countries within a couple.

Debt-to-GDP ratio. To account for the relative indebtedness of the analyzed couples, we calculate the public-debt-to-GDP ratios, defined as the sum of government debt within a couple, divided by the sum of the respective sovereigns' GDP. As postulated by Hypothesis

3, we expect that a higher relative government indebtedness of a couple would lead to a rise in joint probability of distress. Debt-to-GDP has already been considered as a determinant of default risk in prior empirical studies. Uribe and Yue (2006) find that this ratio does not play any significant role in explaining country bond spreads. However, recent studies using CDS spreads and a larger set of countries find a positive and significant effect of this factor (see Hilscher and Nosbusch, 2010; Dieckmann and Plank, 2011).

Our last subset of local variables takes into account the bilateral real economy links and banking relationships within a country-pair. As opposed to the previous local variables which are couple-specific by construction, these two variables are couple-specific by definition.

Bilateral trade. To examine the effect on JPoD of real economy interlinkages between sovereigns, we include in our regressions the logarithm of the sum of bilateral imports and exports within a particular couple. Since the level of trade most likely depends on the relative size of the countries in a pair, as an alternative measure we rescale the total amount of trade by the GDP in 2006 of the smaller country within a couple.[18] Hilscher and Nosbusch (2010) underline the importance of terms of trade in assessing default probabilities on individual country-level. In contrast to this study, however, we focus on trade turnover as a proxy for real economy interlinkages and do not try to compare the welfare gains between the countries within a couple or between a couple and the rest of the world. As postulated in Hypothesis 4, we expect bilateral trade to increase the perceived likelihood of joint sovereign default.

Bilateral banking interconnections. To test our Hypothesis 5, we introduce two proxies that represent the interconnectedness of the banking system. The construction of the variables parallels the one of the bilateral trade proxies. The first one is the logarithm of the sum of reciprocal euro-denominated banking claims within a couple, while the second is the latter sum divided by the GDP in 2006 of the smaller country in a pair. Since three of the sovereigns in our sample (Cyprus, Slovakia and Slovenia) do not report their banking system claims to other countries, we have only access to the claims *on* those countries by the remaining 10 states in our sample. We choose to include a data point on banking claims only when both directions of claims are available. Hence country-pairs containing those three countries are excluded from the regressions, when the bilateral banking claims variables are present.

[18] As a robustness check, we constructed the same variable, but using as a rescaling factor the GDP *time series* of the smaller country. The regression results are virtually the same.

4.4.2 Control Variables

Our control variables reflect general economic conditions within the Euro Area that might have an effect on the repayment ability of the sovereign borrowers considered in our study.

Regional uncertainty. The first variable in our set of controls accounts for the uncertainty in the region, as represented by the 24-month Vstoxx volatility index. This index reflects the implied volatility, derived from options on the Euro Stoxx 50 index. Increasing volatility might be caused by both grim prospects for the overall European Union economy and by market uncertainty about the true fundamental value of the companies on the stock market. We expect that both effects are positively correlated with the probability of sovereign default. Thus a rise in market uncertainty should induce a rise in the default risk of the couples under investigation. Several studies have examined the relative importance of another volatility index (the VIX, reported by the Chicago Board Options Exchange Market) on the sovereign spreads around the world and found concluding evidence which suggest that higher uncertainty leads to higher spreads (see Pan and Singleton, 2008; Hilscher and Nosbusch, 2010; Longstaff et al., 2011)

Term structure of interest rates. Following Duffee (1998) and Collin-Dufresne et al. (2001), we account for the slope of the interest rate term structure by using the difference between the 10-year and the 3-month Euro Area (EA) AAA-bond yields. Schweikhard and Tsesmelidakis (2011) argue that an increase in the slope of the term structure might have an ambivalent effect, reflecting both expectations for improving state of the economy (corresponding in our case to a negative effect on JPoD) and tightened monetary policy due to increase in inflation (positive effect on JPoD).

Market illiquidity. As illiquidity of CDS markets affects CDS prices, and hence the estimation of probabilities of default, we include the spread between EURIBOR and EONIA as a proxy for general illiquidity in the Euro Area. This measure is an alternative to the LIBOR-OIS spread, introduced in Taylor and Williams (2009) and considered by Brunnermeier (2009), Schwarz (2010) and Schweikhard and Tsesmelidakis (2011), which accounts for both illiquidity and counterparty risk. Our expectation is that a rise in illiquidity at Euro Area level should contribute to an increase in the estimated joint probabilities of default. A similar measure has been used in the sovereign debt literature by Hilscher and Nosbusch (2010), albeit based on U.S. data.

4.4.3 Descriptive Statistics

Table 4 presents descriptive statistics in levels of the variables used in our regressions. The mean portfolio return is slightly below zero, reaching both its minimum of -0.69% (February

2009) and maximum of 0.48% (August 2009) for the couple Cyprus-Greece. The average couple Debt-to-GDP level is 73.33%, with the minimum values 10.56 and 148.81 belonging respectively to Slovenia-Ireland (January 2007) and Cyprus-Greece (August 2011). There is a tremendous variation in the rescaled bilateral trade flows within couples. On one hand, there is almost no trade between Cyprus and Slovenia in January 2007 (0.03% of the GDP of Cyprus), while on the other, the trade relations between Belgium and Germany reach 43.08 of the GDP of the former in October 2008. No less interesting are the results for the rescaled bilateral bank claims. Although, on average, those claims seem to be around 20% of the GDP of the smaller country within a couple, this percent ranges from almost non-existent (0.16% of the GDP of Ireland in Greece-Ireland in January 2011) to 116.25% of Ireland's GDP in the couple Germany-Ireland in October 2008.

4.5 Regression Results

We begin our econometric analysis by estimating the model for the entire sample. Next, we focus on certain subperiods and look at how the importance of our explanatory variables has changed over time. To insure that our analysis does not suffer from omitted variable bias, we examine several models that include different sets of explanatory variables.

4.5.1 Overall Period

Table 5 reports the results of first-difference regressions of JPoD on our set of variables for the full sample period. Since the delivered coefficients of the regressions do not have an economic interpretation due to the logistic transformation, we present the corresponding marginal effects, evaluated at the sample mean of the changes of the original variables.

Model (1) includes only the local variables for economic strength and size. One percentage point improvement in business climate seems to reduce the joint likelihood of sovereign default by 0.76 percentage points, while the same level of uncertainty yields an increase by 0.30 percentage points. Both those results support our Hypothesis 1 and are in line with the findings in the literature (see Alexander and Kaeck, 2008; Longstaff et al., 2011). The couple liquidity buffer seem to have insignificant effect, when the rest of the variables are included, while an increase of the joint size by 1% appears to reduce JPoD with more than 4%, as suggested by Hypothesis 2. The latter result is consistent with the findings of Pan and Singleton (2008).

When we include the regional variables in the regression (Model (2)), the absolute level of the business climate and local uncertainty coefficients drops by one third, while the effect of size appears unchanged. Further, we note that the explanatory power of our specification rises by almost 40%. These results suggest that our economic strength variables pick up part of the regional effects and not explicitly controlling for the latter leads to omitted variable bias of the former. The results for the economic strength variables appear to be stable throughout the rest of the specifications, so it is safe to assume that our results reflect the true relationships in the overall sample period. It is interesting to observe that the statistical insignificance of couple liquidity buffers persists across all specifications. Nonetheless, the negative sign is as expected by our Hypothesis 1. Furthermore, the stable effect of economic size suggests that despite the fact that the subprime and the sovereign debt crises seemed to affect not only small bust also large economies, obviously international investors consider the latter group more capable to address solvency issues.

We now turn to the bilateral trade and banking claims results (Models (3) through (10)). Regardless of the definition of the respective variables, the signs for the overall sample period correspond to our Hypotheses 4 and 5. In terms of statistical significance, the results are mixed, with the overall size of those relations appearing not to matter. At the same time the rescaled versions of these variables appear to provide a statistically significant support to our expectations. Nonetheless, we argue that we find fairly straightforward evidence that the real economy and financial channels play a role in forming investors' perceptions about joint sovereign default risk.

In Models (6) and (10), we test Hypothesis 3, i.e. whether debt level relative to GDP affects investors' perceptions with regard to joint sovereign default. To avoid imperfect multicollinearity, in both specifications we exclude the proxy for couple size, since it is highly correlated with the Debt-to-GDP ratio. We find statistically significant support for Hypothesis 3, although the economic significance seems to be limited: 1 percentage point increase in relative indebtedness increases the joint default risk perceptions only by 0.03 percentage points. This result could be due to the heterogeneity of our cross-section, where couples with comparable Debt-to-GDP ratio like Austria-Germany and Ireland-Spain have a very different level of perceived joint default risk. Obviously, the relative indebtedness alone is not a decisive factor for the market's consensus about joint distress risk.

With regard to our regional controls, regional implied volatility has a statistically significant positive effect on joint default probability perceptions. This result is robust across all our specifications and is consistent with the literature on sovereign CDS spreads. The slope of the term structure appears to be insignificant, albeit negative. A similar result is suggested by Duffee (1998), who finds negative but insignificant correlation between corporate bond yields and the slope of the Treasury bill curve between 1985 and 1995. Illiquidity seems to have a positive and significant effect on the perceptions of joint default risk, which is consistent with our expectations and the findings of Hilscher and Nosbusch (2010) for country-specific spreads.

4.5.2 Structural Breaks

In order to analyze the effects of any potential structural breaks due to the subprime and the sovereign debt crises, we divide our sample in 3 subperiods, taking into account major events on the sovereign debt market. For each of the subperiods we repeat our previous estimations. The first subperiod spans from the beginning of 2007 until August 2008. The second subperiod includes the post-Lehman global recession, starting in September 2008 and ending in October 2009, shortly before the Greek government acknowledged their fiscal difficulties. The third subperiod lasts from November 2009 to August 2011 and encompasses the introduction of the European Financial Stability Mechanism, the start of ECB's Securities Markets Programme, as well as several sovereign bailout agreements. This segmentation covers the two main events during our time period that we believe to have influenced outcomes on the sovereign CDS markets.

The results for the first subperiod, presented in Table 6, are somewhat mixed, although the signs of the marginal effects reflect our hypotheses in general. The local variables seem to explain only a very limited part of the dependent variable's variation, evidenced by the adjusted R^2 of 0.07 in Model (1). The results for the most basic extension considered (Model (2)), suggest that the variation in joint default risk is explained primarily by regional factors, as the local variables appear statistically insignificant. Similarly to the entire sample regressions, rising regional volatility and illiquidity increase the expected likelihood of joint defaults. The coefficient of the term spread changes its sign but is still insignificant in explaining the expected JPoD.

The picture changes substantially when only the 10 countries in our sample reporting to the BIS are involved in the couples under investigation (Models (4), (5), (6), (8), (9) and (10)). Surprisingly, improving business climate increases joint default risk, whereas size and relative indebtedness appear to be irrelevant in forming investors default risk perceptions. Moreover, while being insignificant in the estimation on the entire sample, the liquidity buffer appears to be significant across different models for this subperiod. Its sign reflects our hypothesis and underlines the importance of reserves in forming expectations regarding joint default. Overall, our results could reflect the fact that individual Euro Area countries default risk was perceived as very low and the only events that affected the whole region influenced joint default risk.

The second subperiod encompasses the global recession spurred by the collapse of Lehman Brothers. As we showed in Section 3.3 and Figure 5, this episode led to a rise in the perceived JPOD across all couples of EA countries. Most marginal effects, apart from that of liquidity buffers, have the signs predicted by our hypotheses (see Table 7). Furthermore, couple-specific variables that proxy for size and economic strength seem to have a very high explanatory power (see Model 1). Already in our basic specification, these explanatory variables deliver an adjusted R^2 of 0.7 and do not lose their significance when additional controls are included in the model.

Regarding our bilateral variables, as suggested by Hypotheses 4 and 5, higher real economy interconnectedness appears to increase perceived joint default risk, while strong financial interlinkages seem to reduce it. Moreover, when compared to the entire sample estimates of these variables, the significance of bilateral variables seems to increase in this subperiod. Now, even the levels are able to explain variation in the JPoD.

Concerning the regional factors, these variables are significant in very few models. However, the term spread remains a somewhat significant explanatory variable of JPoD. Increases in the term spread are associated with a higher JPoD, possibly suggesting that expectations for tightening monetary policy and a gloomy outlook regarding the state of the EA economy have transferred to the perceptions regarding joint default.

Considering the period after the outbreak of the sovereign debt crisis, we observe an interesting reversal of the effect of local uncertainty on perceptions regarding joint default risk, which violates Hypothesis 1 (see Table 8). In that subperiod, the more uncertain the economic situation appears to be, the lower the predicted joint default risk is. This result appears to be robust across specifications and might be due to overreaction of the stock market to news with regard to the financial situation of Euro Area governments. Apart from that, business climate and liquidity buffers have higher economic significance, compared to the previous subperiod, while size and relative indebtedness are not even statistically significant. Size is important only when no regional variables are included in the model, suggesting that perceptions regarding the JPoD were mostly influenced by the state of the region and not by the size of the countries in each couple. This should come as no surprise given that the crisis has affected both large EA members (e.g. Italy and Spain) and smaller countries (e.g. Greece, Ireland and Portugal).

Furthermore, in the last subperiod, real economy interlinkages appear to play a significant role in forming investors perceptions of joint default risk, providing support to our Hypothesis 3. The marginal effect of financial interconnectedness seems to be with positive sign across our specifications, but mostly insignificant. It seems that the expectations of investors regarding joint default of EA countries are not influenced by how large the country-pairs are, but rather by how interlinked these economies are. In other words, the empirical analysis lends support to the idea that contagion in this subperiod has spread *directly*, through the country-pair bilateral relationships and *indirectly*, via channels related to the overall state of the EA economy.

5 Conclusion

This paper documents the market-perceived probability of joint default of the Euro Area countries during the subprime and the ongoing sovereign debt crisis. For a long time, the currency union was considered an example of a riskless investment environment, but the recent difficulties of several of its members have threatened its very existence, with fears of contagion being predominant throughout 2010 and 2011.

To examine the dependence of sovereign debt issuers in extreme circumstances, we employ a recently developed methodology, the CIMDO approach (Segoviano, 2006; Goodhart and Segoviano, 2009), to model the default region of the distribution of sovereign assets. Using this approach and the resulting CIMDO distribution, we manage to recover the dynamic path of the sovereign joint probability of default between January 2007 and August 2011. This measure allows us to analyze the probability of detrimental events spreading throughout the Euro Area. Furthermore, we bring some important modifications to the original approach and discuss how these changes affect the JPoD measure itself.

The results for our risk measure confirm an increase in the joint probabilities of default after two major events - Lehman Brothers filing for bankruptcy in September 2008, and the outbreak of the Greek sovereign debt crisis at the end of 2009. As expected, the economies that are at the center of the sovereign debt crisis, Greece, Ireland, Italy, Portugal and Spain, exhibit high joint probability of default, with noticeable converging paths of this measure in the last subperiod.

After we have estimated our measure of tail risk, we identify several major factors that affect the pairwise joint probability of default. This analysis is important both from a theoretical and a regulatory perspective, as a precise identification of the driving forces of joint probability of default could lead to better policies addressing financial stability issues in the Euro Area.

Our empirical analysis suggests that higher economic strength and size decrease perceived joint default risk, however size loses its importance after the outbreak of the sovereign debt crisis. Relative indebtedness of sovereigns seems to increase perceived joint default risk, but the effect might not be of economic significance. However, trade interconnections seem to be increasing joint sovereign default risk perceptions during the sovereign debt crisis, suggesting the existence of real economy channels of contagion in that period. Regional factors play an important role in almost all our specifications, implying that investors might expect indirect channels of contagion to affect joint sovereign default risk.

A Figures and Tables

Figure 1: **The importance of the correlation coefficient**. In the first subplot, we present a contour plot of the CIMDO posterior distribution, recovered from a joint standard normal prior. In the second subplot, we add a correlation coefficient of 0.5 to the prior distribution. The upper-right side of the contour plot, where both random variables are above the threshold, has its probability mass changed after introducing correlation.

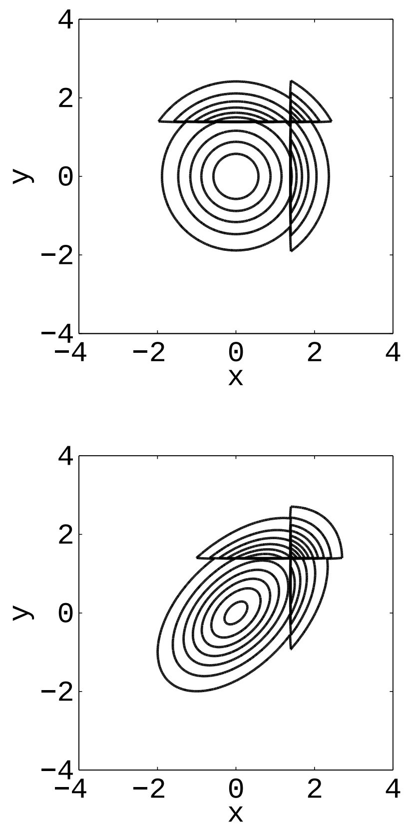

Figure 2: **Comparison between JPoD generated by the CIMDO approach using the bivariate t-distribution and the bivariate normal distribution as a prior**. A common set of parameters is used in both instances. These parameters are set randomly for illustrative purposes. The correlation is fixed at 0.6252. The dotted line represents the JPoD when a bivariate normal density function is assumed as a prior. The individual default probabilities are set at 16.29% and 35.75%. The default threshold is set uniformly at 1.4, corresponding to 8% mass in the right tail. The latter value is the average PoD across time and across all countries in our sample. The solid line stands for the JPoD in the case when a bivariate t-distribution is assumed to be our prior (with different degrees of freedom, ν). The individual default probabilities are set again to 16.29% and 35.75%. Note that the value of the default threshold corresponding to 8% tail mass now changes with the degrees of freedom, due to the fat tails characteristic of the t-distribution.

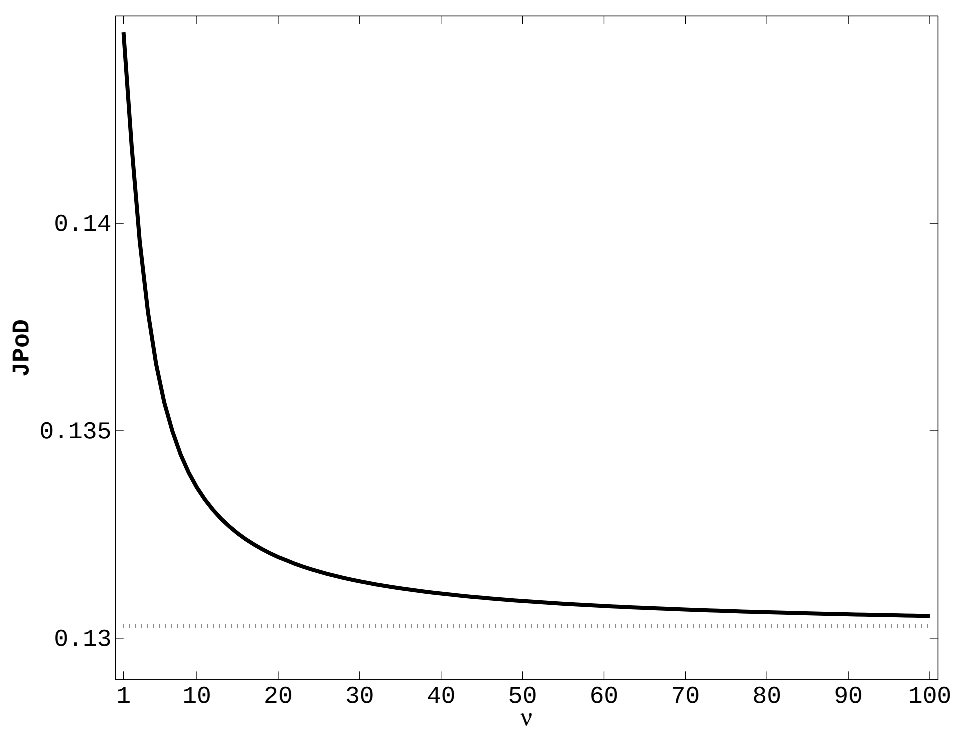

Figure 3: **Estimates for probabilities of default for Greece with different recovery rates**. The probabilities of default are recovered using a bootstrapping procedure, based on Hull and White (2000). These are 5-year probabilities of default. To calculate these probabilities, we use CDS and bond yields' data for Greece as described in Section 3.1.

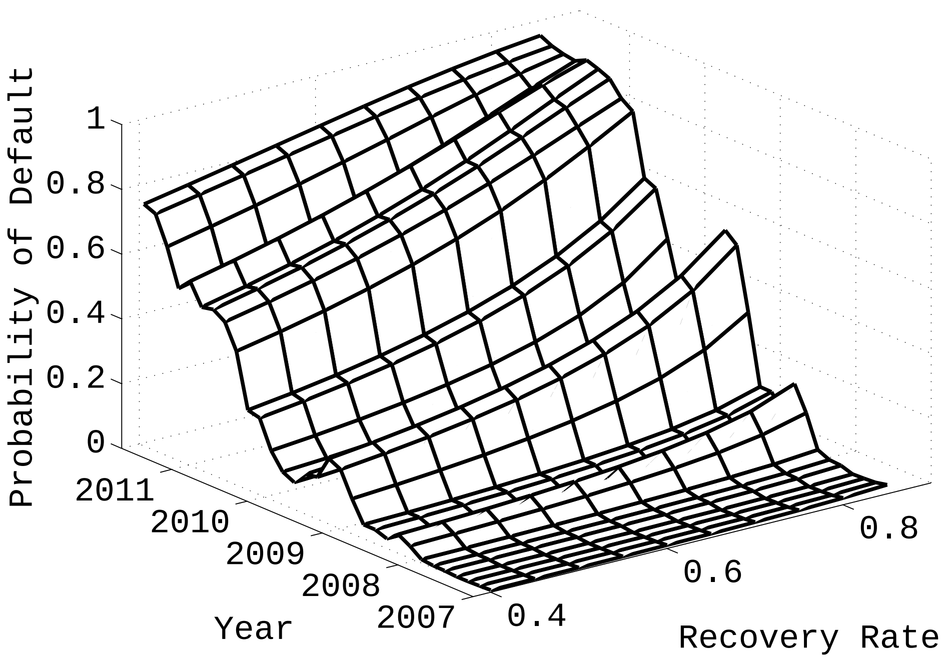

Figure 4: **Estimates for Joint Probabilities of Default for couples with different correlation coefficients**. In this figure, we consider JPoD for three couples with different correlation coefficients. Each line represents the evolution over time of the difference in JPoD. For each of the couples, we construct these differences by subtracting the zero-correlation JPoD measure from the JPoD recovered when some correlation is considered. Differences are depicted as follows: dashed line - Germany and Greece ($\rho = .34$); dotted line - Portugal and Spain ($\rho = .76$); solid line - Greece and Portugal ($\rho = .69$). The black vertical lines mark our cutoff dates, which are used in the estimation part of this paper (first line - September 15, 2008; second line - November 5, 2009)

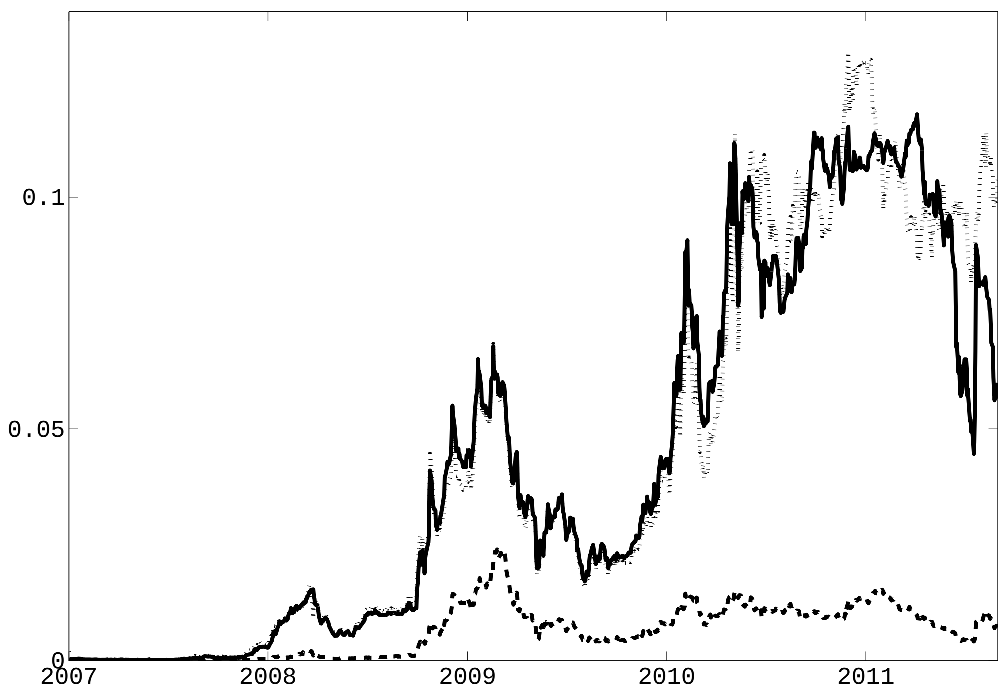

Figure 5: **Estimates for Joint Probabilities of Default**. This chart exhibits the evolution of JPoD over time. All JPoD measures are constructed using non-zero correlation coefficients. The solid line depicts the average JPoD, where daily averages are constructed using equal weights. Dashed lines depict daily JPoD maxima and minima, respectively. The black vertical lines mark our cutoff dates, which are used in the estimation part of this paper (first line - September 15, 2008; second line - November 5)

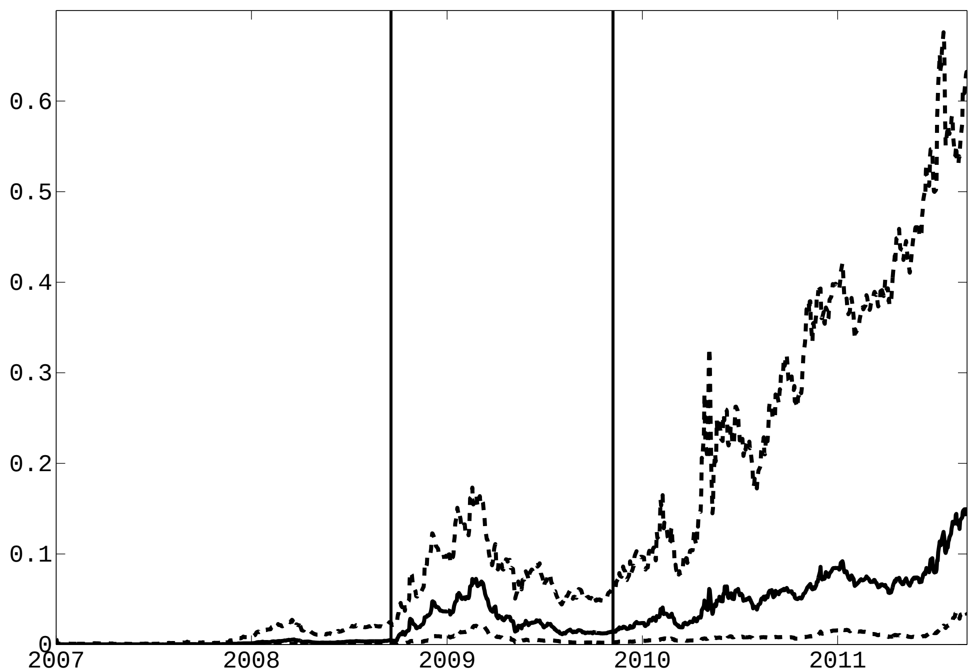

Figure 6: **Joint Probability of Default vs. Conditional Probabilities of Default**. Dotted line: joint probability of default; solid line: conditional probability of default for the first country mentioned in the country-pair names; dashed line: conditional probability of default for the second country mentioned in the country-pair names. Conditional probabilities are contingent on the event of the other country defaulting.

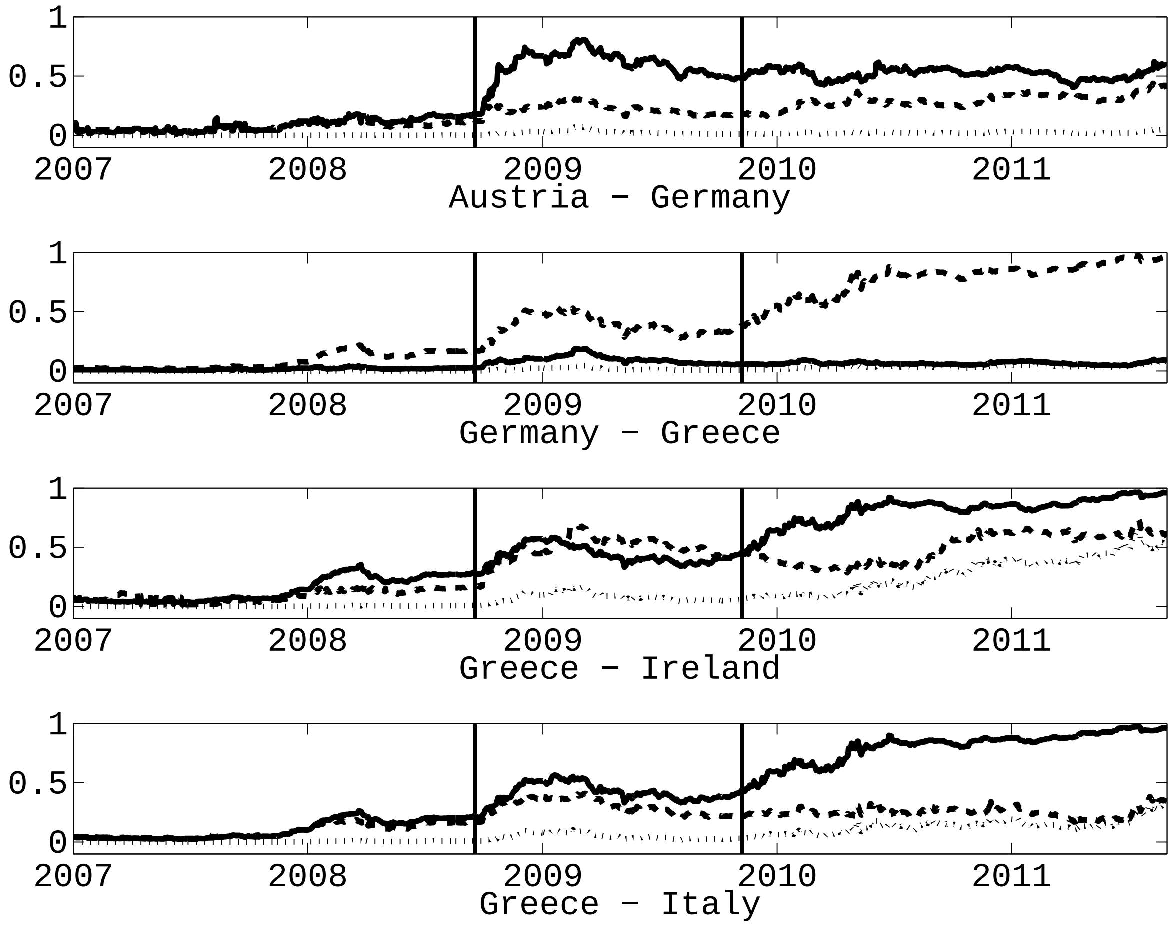

Table 1: **Summary statistics - CDS premia and PoD.** Data on CDS spreads comes from Datastream. Probabilities of default (PoD) are calculated as described in Section 3.1. The number of observations beyond the threshold counts the number of occurrences when the expected default probability is higher than the one predicted by the normal distribution with our default threshold. Abbreviations for country names are as follows (in alphabetical order): Austria, Belgium, Cyprus, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Slovakia, Slovenia, Spain. (Sample size: 1218 daily observations, between January 1, 2007 and August 31, 2011).

	AT	BE	CP	FR	GE	GR	IR	IT	NL	PT	SK	SL	SP
Minimum 5Y CDS Premium (in BPS)	0.50	1.40	1.00	0.50	0.60	4.40	1.75	5.30	1.00	3.40	4.00	3.80	2.47
Mean 5Y CDS Premium (in BPS)	58.88	69.44	124.10	42.04	27.77	417.53	222.01	102.73	33.48	189.65	69.15	64.48	114.83
Maximum 5Y CDS Premium (in BPS)	273.00	266.39	1285.72	170.78	91.85	3086.98	1286.91	386.90	131.00	1295.80	272.50	258.10	425.75
Minimum 5Y PoD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Mean 5Y PoD	0.06	0.07	0.11	0.04	0.03	0.25	0.18	0.10	0.03	0.15	0.07	0.06	0.11
Maximum 5Y PoD	0.24	0.24	0.72	0.16	0.09	0.91	0.69	0.33	0.12	0.70	0.24	0.23	0.35
Threshold	1.58	1.50	1.22	1.73	1.91	0.66	0.93	1.30	1.83	1.03	1.50	1.53	1.25
Probability mass beyond the threshold	0.06	0.07	0.11	0.04	0.03	0.25	0.18	0.10	0.03	0.15	0.07	0.06	0.11

Table 2: **Estimated couple specific correlation coefficients**. The correlation coefficients are calculated for the CDS premia in our sample. Abbreviations for country names are as follows (in alphabetical order): Austria, Belgium, Cyprus, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Slovakia, Slovenia, Spain.

	AT	BE	CP	FR	GE	GR	IR	IT	NL	PT	SK	SL	SP
AT	-	0.58	0.06	0.63	0.66	0.27	0.45	0.54	0.72	0.37	0.48	0.37	0.49
BE		-	0.15	0.72	0.62	0.46	0.64	0.77	0.59	0.64	0.36	0.36	0.75
CP			-	0.12	0.10	0.10	0.12	0.17	0.06	0.16	0.06	0.05	0.12
FR				-	0.76	0.44	0.57	0.68	0.60	0.58	0.40	0.39	0.65
GE					-	0.34	0.51	0.60	0.64	0.49	0.39	0.38	0.58
GR						-	0.64	0.51	0.28	0.69	0.19	0.18	0.53
IR							-	0.67	0.45	0.83	0.26	0.23	0.69
IT								-	0.55	0.73	0.37	0.36	0.88
NL									-	0.38	0.41	0.37	0.50
PT										-	0.25	0.23	0.76
SK											-	0.52	0.31
SL												-	0.30
SP													-

Table 3: **Description of regression variables and data source.**

Variable Name	Description	Data Source
Business Climate	Portfolio of countries' 6-month average individual stock market return, weighted by GDP in 2006 (in %)	Datastream
Local Uncertainty	Average 6-month idividual stock market volatility, weighted by GDP in 2006 (in %)	Datastream
Liquidity Buffer	Logarithm of the sum of countries' total reserves without gold	IMF WEO Database
GDP	Logarithm of the sum of countries' GDP	Bloomberg
Debt-to-GDP	Sum of gross countries' government debt / the sum of countries' GDP (in %)	WB WDI Database and Bloomberg
Bilateral Trade Flow	Logarithm of the sum of countries' bilateral imports and exports, denominated in euro	OECD BTDIxE and Datastream
Rescaled Bilateral Trade Flow	Sum of countries' bilateral imports and exports / minimum GDP in a couple in 2006, denominated in euro (ratio)	OECD BTDIxE and Bloomberg
Bilateral Bank Claims	Logarithm of the sum of countries' bilateral banking claims, denominated in euro	BIS and Datastream
Rescaled Bilateral Bank Claims	Sum of countries' bilateral banking claims / minimum GDP in a couple in 2006, denominated in euro (ratio)	BIS and Bloomberg
Regional Implied Volatility	VSTOXX Index (in %)	Datastream
Term Spread	Difference between the 10-year and the 3-month Euro Area (EA) AAA-bond yields (in %)	ECB SDW
Illiquidity	EURIBOR-EONIA spread (in %)	Datastream

Table 4: **Descriptive statistics of regression variables for the full sample period, from January 2007 to August 2011.**

Variable	Mean	Std. Dev.	Min	Max	Obs
JPoD (logit)	-4.9581	2.3679	-11.2490	0.5290	4368
Business Climate	-0.0241	0.1600	-0.6200	0.4807	4368
Local Uncertainty	1.6032	0.6762	0.4473	3.8916	4368
Liquidity Buffer	9.4318	1.1637	5.7561	11.2883	4368
GDP	11.2380	1.0135	8.2946	12.8459	4368
Debt-to-GDP	73.3344	22.6963	10.5637	148.8133	4368
Bilateral Trade Flow	7.8893	2.3006	1.4521	11.9810	4368
Rescaled Bilateral Trade Flow	0.0588	0.0787	0.0003	0.4318	4368
Bilateral Bank Claims	9.2676	1.5288	4.5804	11.9488	2464
Rescaled Bilateral Bank Claims	0.1943	0.1930	0.0016	1.1626	2464
Regional Implied Volatility	27.5788	9.0958	15.7900	60.6800	4368
Term Spread	1.5692	1.0600	-0.1400	3.0240	4368
Illiquidity	0.4155	0.2879	-0.2390	1.1730	4368

Table 5: **Determinants of Joint Probability of Default: Overall Sample.** This table reports marginal effects from first-differences logit regressions of the JPoD on the list of variables, outlined in Subsection 4.4, for the entire sample period from January 2007 to August 2011. We consider 78 country-pairs (couples) in these regressions. The frequency is monthly, resulting in 56 time periods per couple. All specifications include couple fixed effects. The numbers in parentheses are p-values. All standard errors are clustered by country. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Business Climate	-0.7573***	-0.4979***	-0.4929***	-0.3484***	-0.3445***	-0.3245***	-0.4966***	-0.3539***	-0.3525***	-0.3343***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Local Uncertainty	0.3090***	0.1976***	0.1944***	0.2229***	0.2191***	0.2181***	0.1966***	0.2226***	0.2203***	0.2203***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Liquidity Buffer	0.0062	-0.0103	-0.0086	-0.0669	-0.0641	-0.0815	-0.0103	-0.0658	-0.0649	-0.0823
	(0.616)	(0.507)	(0.572)	(0.363)	(0.380)	(0.289)	(0.507)	(0.371)	(0.375)	(0.287)
GDP	-4.3638***	-4.4605***	-4.4737***	-5.3225***	-5.2435***		-4.454***	-5.3393***	-5.2869***	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	
Debt-to-GDP						0.0308***				0.0323***
						(0.007)				(0.010)
Bilateral Trade Flow			0.0862*		0.0931	0.1164				
			(0.072)		(0.302)	(0.192)				
Bilateral Bank Claims				-0.0879	-0.0994	-0.1077				
				(0.348)	(0.335)	(0.315)				
Rescaled Bilateral Trade Flow							0.3283		0.7699**	0.8091**
							(0.289)		(0.029)	(0.032)
Rescaled Bilateral Bank Claims								-0.5971***	-0.6921***	-0.7638***
								(0.000)	(0.000)	(0.000)
Regional Implied Volatility		0.0126***	0.0125***	0.0134***	0.0132***	0.0132***	0.0126***	0.0134***	0.0133***	0.0134***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Term Spread		-0.0054	-0.0054	-0.0174	-0.0175	-0.0036	-0.0055	-0.0179	-0.0182	-0.0046
		(0.627)	(0.627)	(0.213)	(0.211)	(0.818)	(0.624)	(0.208)	(0.203)	(0.778)
Illiquidity		0.0631***	0.0598***	0.0418***	0.0387***	0.0326***	0.0623***	0.0428***	0.0415***	0.0365***
		(0.000)	(0.000)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.000)
Observations	4290	4290	4290	2420	2420	2420	4290	2420	2420	2420
Adjusted R-squared	0.255	0.348	0.348	0.373	0.372	0.369	0.348	0.373	0.373	0.369

Table 6: **Determinants of Joint Probability of Default: Pre-Lehman Period.** This table reports marginal effects from first-differences logit regressions of the JPoD on the list of variables, outlined in Subsection 4.4, for the period from January 2007 to August 2008. We consider 78 country-pairs (couples) in these regressions. The frequency is monthly, resulting in 20 time periods per couple. All specifications include couple fixed effects. The numbers in parentheses are p-values. All standard errors are clustered by country. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Business Climate	-1.5414***	-0.0069	0.0397	0.3470***	0.2714***	0.2996***	0.0073	0.3446***	0.3297***	0.3487***
	(0.000)	(0.954)	(0.732)	(0.003)	(0.010)	(0.007)	(0.948)	(0.009)	(0.009)	(0.008)
Local Uncertainty	-0.1383	-0.0263	-0.0354	0.4670**	0.4756**	0.5069**	-0.0299	0.4652**	0.4731**	0.5060**
	(0.481)	(0.866)	(0.824)	(0.028)	(0.027)	(0.018)	(0.851)	(0.027)	(0.027)	(0.018)
Liquidity Buffer	-0.3157**	-0.2156	-0.2239	-0.8138**	-0.7973**	-0.7890**	-0.2171	-0.8080**	-0.8057**	-0.7961**
	(0.029)	(0.116)	(0.102)	(0.043)	(0.046)	(0.049)	(0.115)	(0.044)	(0.045)	(0.047)
GDP	3.8709	2.1333	1.6249	1.4957	3.0488		1.8998	1.3005	1.7666	
	(0.304)	(0.479)	(0.623)	(0.534)	(0.293)		(0.536)	(0.607)	(0.505)	
Debt-to-GDP						0.0055				0.023
						(0.893)				(0.560)
Bilateral Trade Flow			-0.4056		0.6185	0.5321				
			(0.368)		(0.151)	(0.196)				
Bilateral Bank Claims				-0.1431	-0.2246*	-0.2032				
				(0.350)	(0.089)	(0.125)				
Rescaled Bilateral Trade Flow							-2.1286		2.6746	2.2761
							(0.487)		(0.175)	(0.218)
Rescaled Bilateral Bank Claims								-0.4256	-0.5968	-0.5745
								(0.494)	(0.344)	(0.345)
Regional Implied Volatility		0.0378***	0.0375***	0.0377***	0.0382***	0.0384***	0.0377***	0.0378***	0.0379***	0.0382***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Term Spread		0.0363	0.0357	0.013	0.0157	0.0224	0.0359	0.0132	0.0146	0.0216
		(0.491)	(0.500)	(0.707)	(0.659)	(0.546)	(0.496)	(0.709)	(0.679)	(0.558)
Illiquidity		0.5044***	0.4941***	0.4600***	0.4741***	0.4743***	0.5012***	0.4610***	0.4652***	0.4669***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1482	1482	1482	836	836	836	1482	836	836	836
Adjusted R-squared	0.070	0.264	0.264	0.324	0.325	0.325	0.264	0.324	0.324	0.324

Table 7: **Determinants of Joint Probability of Default: Post-Lehman - Pre-Sovereign Debt Crisis Period.** This table reports marginal effects from first-differences logit regressions of the JPoD on the list of variables, outlined in Subsection 4.4, for the period from September 2008 to October 2009. We consider 78 country-pairs (couples) in these regressions. The frequency is monthly, resulting in 14 time periods per couple. All specifications include couple fixed effects. The numbers in parentheses are p-values. All standard errors are clustered by country. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Business Climate	-0.4202***	-0.3438***	-0.2607***	-0.3818***	-0.3347***	-0.3027***	-0.3402***	-0.3544***	-0.3527***	-0.3305***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.004)	(0.007)	(0.000)	(0.003)	(0.003)	(0.003)
Local Uncertainty	0.5159***	0.4396***	0.4100***	0.4427***	0.4221***	0.4225***	0.4377***	0.4400***	0.4380***	0.4488***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Liquidity Buffer	0.0479	0.0705**	0.0725**	0.4834***	0.4685***	0.4474***	0.0698**	0.4676***	0.4664***	0.4429***
	(0.172)	(0.027)	(0.018)	(0.002)	(0.002)	(0.002)	(0.028)	(0.001)	(0.002)	(0.002)
GDP	-6.1191***	-6.6557***	-4.8929**	-8.6115***	-7.0160***		-6.5434***	-8.8362***	-8.7186***	
	(0.003)	(0.001)	(0.013)	(0.005)	(0.004)		(0.002)	(0.004)	(0.006)	
Debt-to-GDP						0.0795***				0.1039***
						(0.003)				(0.002)
Bilateral Trade Flow			0.6472***		0.4438**	0.6019**				
			(0.003)		(0.017)	(0.016)				
Bilateral Bank Claims				-0.4070***	-0.5322***	-0.5582***				
				(0.002)	(0.000)	(0.001)				
Rescaled Bilateral Trade Flow							0.4807***		0.4136***	0.4919***
							(0.650)		(0.475)	(0.323)
Rescaled Bilateral Bank Claims								-0.7755***	-0.8420***	-0.7498***
								(0.008)	(0.004)	(0.001)
Regional Implied Volatility		0.0046**	0.0035**	0.0027	0.0023	0.0019	0.0045**	0.0025	0.0025	0.0021
		(0.013)	(0.046)	(0.276)	(0.338)	(0.404)	(0.011)	(0.274)	(0.282)	(0.341)
Term Spread		0.0895**	0.0923**	0.1186*	0.1167*	0.1214**	0.0897**	0.1216**	0.1215**	0.1297**
		(0.033)	(0.027)	(0.054)	(0.057)	(0.048)	(0.032)	(0.045)	(0.044)	(0.031)
Illiquidity		0.0088	-0.0348	0.0028	-0.0192*	-0.0318**	0.0065	-0.0152*	-0.0164*	-0.0233**
		(0.687)	(0.114)	(0.648)	(0.065)	(0.029)	(0.783)	(0.096)	(0.095)	(0.024)
Observations	1092	1092	1092	616	616	616	1092	616	616	616
Adjusted R-squared	0.703	0.752	0.757	0.819	0.820	0.819	0.752	0.814	0.814	0.812

Table 8: **Determinants of Joint Probability of Default: Sovereign Debt Crisis Period.** This table reports marginal effects from first-differences logit regressions of the JPoD on the list of variables, outlined in Subsection 4.4, for the period from November 2009 to August 2011. We consider 78 country-pairs (couples) in these regressions. The frequency is monthly, resulting in 22 time periods per couple. All specifications include couple fixed effects. The numbers in parentheses are p-values. All standard errors are clustered by country. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Business Climate	-0.9281***	-0.5509***	-0.5830***	-0.4287***	-0.4771***	-0.4985***	-0.5533***	-0.4233***	-0.4338***	-0.4573***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Local Uncertainty	-0.0235	-0.0979***	-0.0964***	-0.0839***	-0.0888***	-0.0984***	-0.0954***	-0.0883***	-0.0869***	-0.0975***
	(0.338)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.002)
Liquidity Buffer	-0.1465	-0.2615*	-0.3094*	-0.3987*	-0.5058**	-0.5332**	-0.3011*	-0.4275*	-0.4596**	-0.4888**
	(0.360)	(0.097)	(0.070)	(0.065)	(0.024)	(0.019)	(0.070)	(0.051)	(0.044)	(0.034)
GDP	-4.9962***	-1.7007	-1.3909	-5.1628*	-3.8625		-1.7105	-4.3386*	-4.3210*	
	(0.004)	(0.299)	(0.397)	(0.059)	(0.130)		(0.298)	(0.092)	(0.092)	
Debt-to-GDP						0.0221				0.0248
						(0.411)				(0.358)
Bilateral Trade Flow			0.4316*		0.7027***	0.7120***				
			(0.075)		(0.001)	(0.001)				
Bilateral Bank Claims				0.1006	0.0431	0.036				
				(0.264)	(0.650)	(0.707)				
Rescaled Bilateral Trade Flow							2.8052**		2.5123***	2.4942***
							(0.012)		(0.002)	(0.002)
Rescaled Bilateral Bank Claims								1.0115*	0.7271	0.6913
								(0.076)	(0.194)	(0.217)
Regional Implied Volatility		0.0162***	0.014***	0.0162***	0.0128***	0.0129***	0.0154***	0.0162***	0.0154***	0.0155***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Term Spread		0.0586***	0.0588***	0.0597***	0.0555***	0.0598***	0.0583***	0.0648***	0.0616***	0.0667***
		(0.009)	(0.010)	(0.003)	(0.008)	(0.005)	(0.009)	(0.003)	(0.005)	(0.003)
Illiquidity		0.0195	0.0147	0.0204*	0.0137	0.0145	0.0175	0.0187	0.0186	0.0194
		(0.160)	(0.349)	(0.089)	(0.171)	(0.156)	(0.211)	(0.130)	(0.123)	(0.120)
Observations	1716	1716	1716	968	968	968	1716	968	968	968
Adjusted R-squared	0.193	0.452	0.460	0.438	0.457	0.455	0.456	0.441	0.444	0.442

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