Granger-Causality in peripheral EMU public debt markets: A dynamic approach

Marta Gómez-Puig[a], Simón Sosvilla-Rivero[b, *]
[a.] Department of Economic Theory, Universitat de Barcelona. 08034 Barcelona, Spain
[b.] Department of Quantitative Economics, Universidad Complutense de Madrid. 28223 Madrid, Spain

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Abstract

Our research aims to analyze the possible existence of Granger-causal relationships in the behavior of public debt issued by peripheral member countries of the European Economic and Monetary Union (EMU), with special emphasis on the recent episodes of crisis triggered in the eurozone sovereign debt markets since 2009. With this goal in mind, we make use of a database of daily frequency of yields on 10-year government bonds issued by five EMU countries (Greece, Ireland, Italy, Portugal and Spain), covering the entire history of the EMU from its inception on 1 January 1999 until 31 December 2010. In the first step, we explore the pair-wise Granger-causal relationship between yields, both for the whole sample and for changing subsamples of the data, in order to capture the possible time-varying causal relationship. This approach allows us to detect episodes of significant increase in Granger-causality between yields on bonds issued by different countries. In the second step, we study the determinants of these episodes, analyzing the role played by different factors, paying special attention to instruments that capture the total national debt (domestic and foreign) in each country.

Keywords: Sovereign bond yields, Granger-causality, time-varying approach, euro area, peripheral EMU countries.

JEL Classification Codes: E44, F36, G15

[*.] Corresponding author. Tel.: +34 913942342; fax: +34 913942591.

E-mail addresses: marta.gomezpuig@ub.edu (M. Gómez-Puig), sosvilla@ccee.ucm.es (S. Sosvilla-Rivero)

1. Introduction

After ten years of stability, the financial and economic crisis that followed the US subprime crisis and Lehman Brothers collapse highlighted the imbalances within the European Economic and Monetary Union (EMU) countries. These imbalances had probably been undervalued during the stability period when markets seemed to underestimate the possibility that governments might default. Nevertheless, from August 2007 onwards, in parallel with the rise in global financial instability that led to a "flight-to-quality", yield spreads of euro area issues with respect to Germany spiraled (see Figure 1). Moreover, since 2010, Greece has been bailed out twice and the Republic of Ireland and Portugal also needed bailouts to stay afloat. These events brought to light the fact that the origin of sovereign debt crises in Europe could even go beyond the imbalances in public finances.

Indeed, the main causes of the debt crises in Europe vary according to the country and reflect an important interconnection between public and private debt. In Ireland, the crisis was mainly due to the private sector, particularly a domestic housing boom which was financed by foreign borrowers who did not require a risk premium related to the probability of default (see Lane, 2011). In Spain, since absorption exceeded production, the external debt grew and the real exchange rate appreciated, implying a loss of competitiveness for the economy. Unlike previous expansions, the resort to financing was not led by the public sector but by private households and firms. In contrast to Ireland and Spain, the origin of the debt crisis in Greece and Portugal was the structural deficit in the government sector. If the crisis spreads to Italy, this structural deficit would be the possible cause. Greece and Italy's large fiscal deficit and huge public debt are the cumulative result of chronic macroeconomic imbalances[1]. However, the case of Portugal illustrates the importance of external debt[2] (specifically, that of its private sector: banks and enterprises).

[1] As pointed out in Gómez-Puig (2006 and 2008), in the past, Italy may have benefited from the fact that "size matters for liquidity" and thus for the success of a sovereign debt market since at the end of 2010 its market was the biggest in the euro area.

[2] The current account deficit over GDP was 9.86% in December 2010.

Some studies have already found a strong relationship between risk premium and a wide range of vulnerability indicators that go beyond the fiscal position. The IMF (2010) and Barrios *et al.* (2009) present empirical evidence of the strong relationship between current account deficits and foreign debt and the behavior of sovereign risk premium. Moreover, Gros (2011) contends that foreign debt is more important than public debt, and that this may have a number of implications for the ongoing eurozone crisis[3].

Other authors (Bolton and Jeanne (2011) and Allen *et al.* (2011), to name a few), have focused on the study of cross-border banking system linkages to the government sector. Although, cross-border banking effect on risk diversification is a key benefit, foreign capital is likely to be more mobile than domestic capital and, in a crisis situation, foreign banks may simply decide to "cut and run". In addition, in an integrated banking system, financial or sovereign crisis in a country can quickly spill over to other countries. In this context, it is important to note that the European Union and, especially the euro area, witnessed a significant increase in cross-border financial activity over the ten years before the global crisis (see Barnes, Lane and Radziwill, 2010). Both the elimination of currency risk and regulatory convergence[4] can explain this important increase (see Kalemli-Ozcan, Papaioannou and Peydró-Alcalde, 2009). Spiegel (2009a and 2009b) shows that the effect of the monetary union has been even stronger for some of the peripheral EMU countries. In particular, the sources of external financing for Portuguese and Greek banks radically shifted on joining the euro; traditionally reliant on dollar debt, these banks were subsequently able to raise funds from their counterparts elsewhere in the EMU.

Therefore, in this scenario of increased cross-border financial activity in the euro area, Gray *et al.* (2008) point out the importance of identifying the channels that connect the banking and the sovereign sectors, not only within a country but across countries as well. On the one hand, a

[3] This author points out that the importance of external debt is due to the fact that euro area governments retain full sovereignty over the taxation of their citizens, but they are bound by existing treaties and international norms and do not have a free hand in taxing non-citizens. Therefore, euro countries can always service their domestic debt, even without access to the printing press, but not their external debt.

[4] The introduction of the Single Banking License in 1989 through the Second Banking Directive was a decisive step towards a unified European financial market, which subsequently led to a convergence in financial legislation and regulation across member countries.

systemic banking crisis can induce a contraction of the entire economy, weakening public finances and thus transferring the distress to the government. This effect is amplified when the financial sector has state guarantees. As a feedback effect, risk is further transmitted to holders of sovereign debt. On the other hand, macroeconomic imbalances in a specific country lead to rising sovereign spreads and a devaluation of the government debt that is mirrored in banks' balance sheets. Moreover, as the recent European sovereign debt crisis has stressed, transmission of the crisis in one country to others through the banking system can be a major issue.

The recent literature on sovereign debt has not studied these linkages in depth. Only a handful of recent papers have addressed the interaction between sovereign default and the stability of the domestic financial system. The analyses by Mody (2009), Ejsing and Lemke (2009), Gennaioli, Martin and Rossi (2010) and Broner, Martin and Ventura (2010), are among them[5]. The papers most closely related to our analysis are the studies by Bolton and Jeanne (2011) and Andenmatten and Brill (2011). Bolton and Jeanne's (2011) central issue is the analysis of the international contagion caused by the banks' exposure to the sovereign risk of foreign countries. To that end, they use data from the 2010 European stress test and show that financial integration without fiscal integration results in an inefficient equilibrium supply of government debt[6]. Andenmatten and Brill (2011) perform a bivariate test for contagion that is based on an approach proposed by Forbes and Rigobon (2002) to examine whether the co-movement of sovereign CDS premium increased significantly after the beginning of the Greek debt crisis in October 2009. Unlike Forbes and Rigobon, they conclude that in European countries "both contagion and interdependence" occurred.

However, an important constraint in the above-mentioned empirical evidence is the fact that it ignores the dynamic component of the degree of interconnection of public debt markets. In this

[5] Beakert *et al.* (2011) analyze the transmission of crises to country-industry equity portfolios in 55 countries, using the 2007-2009 financial crisis as a laboratory.

[6] The same conclusion is reached by Gros and Mayer (2011) who say that "The EU resembles a group of highly interdependent companies with large cross-holdings of equity stakes. However, the formal structure of the group is very light. There is no central authority that can give orders to individual members of the group". They conclude that the euro area can no longer avoid a stark choice: "either it sticks to the limited liability character of EMU (but in this case sovereign default becomes likely), or it moves towards a fiscal union with a mutual guarantee for the public debt of all member countries".

regard, Abad, Chuliá and Gómez-Puig (2010 and 2012) examine the European government bond market integration from a dynamic perspective, applying an asset pricing model to a dataset spanning the years 2004 to 2009[7]. Nonetheless, the evolution of the time-varying degree of causality of EMU sovereign debt yields behavior (and the factors behind it, especially the role played by private debt and cross-border banking linkages) has not yet been analyzed in sufficient depth by the literature. This paper aims to carry out an analysis of this kind.

Thus, the main objectives of this paper are threefold: (1) to test for the existence of possible Granger-causal relationships between the evolution of the yield of bonds issued by peripheral EMU countries, (2) to examine the time-varying nature of these Granger-causal relationships and to detect episodes of significant increase in causality between them, and (3) to analyze the determinants of those events considering not only macroeconomic imbalances, but also the role played by private debt, cross-border banking linkages, indicators of investor sentiment and variables that capture global risk and liquidity. This paper also makes three main contributions to the existing literature. First, it presents a dynamic approach to the analysis of the evolution of the degree of Granger-causality of EMU sovereign debt yields behavior. Second, it makes use of a unique dataset on private debt-to-GDP by sector (households, banks and non-financial corporations) in each EMU country and on cross-border banking linkages. Private debt dataset has been built up by the authors using the Monetary Financial Institutions (MFI) balance sheet statistics provided for each euro country by the European Central Bank, whilst cross border banking linkages are measured using the consolidated claims on an immediate borrower basis of Bank for International Settlements reporting banks (in the public, the banking and the non-financial private sectors). Third, it focuses the analysis on peripheral EMU countries (Greece, Ireland, Italy, Portugal and Spain), since these are the countries which have come under market pressure since 2009, reflecting investors' perceptions of risks, and which to a large extent have been the origin of the current sovereign debt crisis in the whole eurozone.

[7] Their results suggest that, from the beginning of the financial market tensions in August 2007, markets moved towards higher segmentation, and the differentiation of country risk factors increased substantially across countries. Although the levels were very low, the persistence of positive yield spreads against Germany detected before the beginning of the crisis (see Gómez-Puig, 2009a and 2009b) was still a reflection of incomplete integration in EMU bond markets.

The most important results of the analysis can be summarized as follows. Firstly, we provide empirical evidence of the existence of sub-periods of Granger-causality in all pair-wise relationships. Secondly, we also present empirical evidence which indicates that the Granger-causality relationships between peripheral EMU yields have significantly increased during the recent crises in sovereign debt markets from 2009. Thirdly, the results of the Probit models estimated to analyze the determinants of the episodes of Granger-causality intensification show that in all cases the variable that captures cross-border banking linkages is statistically significant. This finding might suggest that, not only macroeconomic imbalances may be key determinants of the probability of occurrence of those episodes, but in a scenario of increased international financial activity in the euro area, transmission of the crisis in one country to other countries through the banking system can be a major issue. Lastly, the results support the important role played by private debt, especially in the cases of Spain and Italy.

The rest of the paper is organized as follows. Section 2 presents the Granger-causality analysis and our approach for the detection of episodes of increase in Granger-causality. In Section 3 we carry out the exploration of the determinants of these episodes. Finally, Section 4 summarizes the findings and offers some concluding remarks.

2. Granger-causality analysis

2. 1. Econometric methodology

The concept of Granger-causality was introduced by Granger (1969) and Sims (1972) and is widely used to ascertain the importance of the interaction between two series. The central notion is one of predictability (Hoover, 2001): one variable Granger-causes some other variable, given an information set, if past information about the former can improve the forecast of the latter based only in its own past information. Therefore, the knowledge of one series evolution reduces the forecast errors of the other, suggesting that the latter does not evolve independently of the former.

Testing Granger causality typically employs the same lags for all variables. This poses a potential problem, since Granger-causality tests are sensitive to lag length. Therefore, it is important that the lengths selected should be the right ones to avoid inconsistently estimating the model and drawing misleading inferences (see, Thornton and Batten, 1985). In determining the optimal lag structure for each variable, we follow Hsiao's (1981) sequential method to test for causality, which combines Akaike's final predictive error (FPE, from now on) and the definition of Granger-causality[8]. Essentially, the FPE criterion trades off bias that arises from under-parameterization of a model against a loss in efficiency resulting from over-parameterization of the model, removing us from the ambiguities of the conventional procedure.

Consider the following models,

$$X_t = \alpha_0 + \sum_{i=1}^{m} \delta_i X_{t-i} + \varepsilon_t \qquad (1)$$

$$X_t = \alpha_0 + \sum_{i=1}^{m} \delta_i X_{t-i} + \sum_{j=1}^{n} \gamma_j Y_{t-j} + \varepsilon_t \qquad (2)$$

where X_t and Y_t are stationary variables [i.e., they are I(0) variables]. The following steps are used to apply Hsiao's procedure for testing Granger-causality:

i) Treat X_t as a one-dimensional autoregressive process (1), and compute its FPE with the order of lags m varying from 1 to m[9]. Choose the order which yields the smallest FPE, say m, and denote the corresponding FPE as FPE_X (m, 0).

ii) Treat X_t as a controlled variable with m number of lags, and treat Y_t as a manipulated variable as in (2). Compute again the FPE of (2) by varying the order of lags of Y_t from 1 to n, and determine the order which gives the smallest FPE, say n, and denote the corresponding FPE as FPE_X (m,n)[10].

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[8] Thornton and Batten (1985) show that the Akaike's FPE criterion performs well relative to other statistical techniques.

[9] $FPE_X(m,0)$ is computed using the formula: $FPE_X(m,0) = \frac{T+m+1}{T-m-1} \cdot \frac{SSR}{T}$, where T is the total number of observations and SSR is the sum of squared residuals of OLS regression (1)

[10] $FPE_X(m,n)$ is computed using the formula: $FPE_X(m,n) = \frac{T+m+n+1}{T-m-n-1} \cdot \frac{SSR}{T}$, where T is the total number of observations and SSR is the sum of squared residuals of OLS regression (2)

iii) Compare FPE_X (m, 0) with FPE_X (m,n) [i.e., compare the smallest FPE in step (i) with the smallest FPE in step (ii)]. If FPE_X (m,0) > FPE_X (m,n), then Y_t is said to cause X_t. If FPE_X (m,0) < FPE_X (m,n), then X_t is an independent process.

iv) Repeat steps i) to iii) for the Y_t variable, treating X_t as the manipulated variable.

When X_t and Y_t are not stationary variables, but are first-difference stationary [i.e., they are I(1) variables] and cointegrated (see Dolado *et* al., 1990), it is possible to investigate the existence of a Granger-causal relationships from ΔX_t to ΔY_t and from ΔY_t to ΔX_t, using the following error correction models:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{m} \delta_i \Delta X_{t-i} + \varepsilon_t \qquad (3)$$

$$\Delta X_t = \alpha_0 + \beta Z_{t-1} + \sum_{i=1}^{m} \delta_i \Delta X_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta Y_{t-j} + \varepsilon_t \qquad (4)$$

where Z_t is the OLS residual of the cointegrating regression ($X_t = \mu + \lambda Y_t$), known as the error-correction term. Note that, if X_t and Y_t are I (1) variables, but they are not cointegrated, then β in (4) is assumed to be equal to zero.

In both cases [i.e., X_t and Y_t are I(1) variables, and they are or are not cointegrated], we can use Hsiao's sequential procedure substituting X_t with ΔX_t and Y_t with ΔY_t in steps i) to iv), as well as substituting expressions (1) and (2) with equations (3) and (4). Proceeding in this way, we ensure efficiency since the system is congruent and encompassing (Hendry and Mizon, 1999).

2. 2. Data

We use daily data of 10-year bond yields from 1 January 1999 to 31 December 2010 collected from Thomson Reuters Datastream for EMU peripheral countries: Greece, Ireland, Italy, Portugal and Spain. Figures 1a and 1b plot the evolution of daily 10-year sovereign bond yields and their spread against the bund for each country in our sample. A simple look at these figures indicates the differences in the yields behavior before and after the financial crisis of 2008.

[Insert Figures 1a and 1b here]

Specifically, it is remarkable that after the introduction of the euro in January 1999 and until the subprime crisis in global financial markets in August 2007, spreads on bonds of EMU peripheral countries moved in a narrow range with only slight differentiation across countries. In fact, the stability and convergence of spreads was considered a hallmark of successful financial integration inside the euro area. Nevertheless, after the subprime crisis in 2007, severe tensions emerged in financial markets worldwide, including the EMU bond market. Moreover, following the collapse of the US financial institution Lehman Brothers on 15 September 2008, the financial turmoil turned into a global financial crisis which began to spread to the real sector.

Therefore, the financial crisis highlighted the imbalances within the euro area and yield spreads between government bond issues of participating countries, which had reached levels close to zero between 2003 and 2007 (the average value of the 10-year yield spread against the German bund moved between -4 and 20 basis points, in the case of Ireland and Greece, respectively), reemerged. Indeed, the risk premium on EMU government bonds increased strongly in 2008, reflecting investor perceptions of upcoming risks. Concretely, Figure 1b displays that by the end of December 2010 it reached levels of 952 basis points in Greece, 580 in Ireland, 380 in Portugal, 255 in Spain and 182 in Italy.

[Insert Table 1 here]

Table 1 presents descriptive statistics for the levels and differences of the 10-year government's yield in peripheral EMU countries during the sample period (1999-2010). As can be seen, the mean is not significantly different from zero for the first differences. Normality is tested with the Jarque-

Bera test (which is distributed as $\chi^2(2)$ under the null) and strongly rejected for both the levels and first differences. Since rejection could be due to either excess of kurtosis or skewness, we report these statistics separately in Table 1. Given that the kurtosis of the normal distribution is 3, our results suggest that the distribution of the yields of Greece and Ireland, as well as all the first differences, are peaked relative to the normal, while the distribution of the yields in the cases of Italy, Portugal and Spain are flat relative to the normal. Finally, regarding the asymmetry of the distribution of the series around their mean, we find positive skewness for all the variables in levels and for the first difference in the case of Italy, suggesting that their distributions have long right tails, whilst in the cases of the first differences of yields for Greece, Ireland, Portugal and Spain there is evidence of negative skewness and therefore of distributions with long left tails.

2.3. Preliminary results

As a first step, we tested for the order of integration of the 10-year bond yields by means of the Augmented Dickey-Fuller (ADF) tests. The results, shown in Table 2, decisively reject the null hypothesis of non stationarity, suggesting that both variables can be treated as first-difference stationary[11].

[Insert Table 2 here]

Following Carrion-i-Silvestre *et al.* (2001)'s suggestion, we confirm this result using the Kwiatkowski *et al.* (1992) (KPSS) tests, where the null is a stationary process against the alternative of a unit root. As can be seen in Table 3, the results fail to reject the null hypothesis of stationarity in first differences, but strongly reject it in levels.

[Insert Table 3 here]

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[11] These results were confirmed using Phillips-Perron (1998) unit root tests controlling for serial correlation and the Elliott, Rothenberg, and Stock (1996) Point Optimal and Ng and Perron (2001) unit root tests for testing non-stationarity it against the alternative of high persistence. These additional results are not shown here to save space, but they are available from the authors upon request.

As a second step, we tested for cointegration between each of the 10 pair combinations[12] of peripheral EMU yields using Johansen (1991, 1995)'s approach. An important decision in this approach is whether to include deterministic terms in the cointegrating Vector Autoregressive (VAR) model. Deterministic terms, such as the intercept, linear trend, and indicator variables, play a crucial role in both data behavior and limiting distributions of estimators and tests in integrated processes. Banerjee *et al.* (1993), Johansen (1994) and Nielsen and Rahbek (2000) show that the statistical properties of the commonly used test procedure are affected, indicating that in some cases its size cannot be controlled, and that in others there is substantial power loss. Depending on their presence or absence, the system may manifest drift, linear trends in cointegration vectors, or even quadratic trends. In practical work, there seem to be only two relevant model representations for the analysis of cointegration amongst most economic time series variables:

i. the level data have no deterministic trend and the cointegrating equations have intercepts; and

ii. the level and the cointegrating equations have linear trends.

Table 1 shows that the hypothesis of the expected values of the first differences of the series is equal to zero can not be rejected; hence, there is no evidence of linear deterministic trends in the data. The graphs in Figure 1a support this finding. Therefore, we conclude that the cointegrated VAR model should be formulated according to i), with the constant term restricted to the cointegration space, and no deterministic trend terms. This implies that some equilibrium means are different from zero.

As can be seen in Table 4, only for the Greece-Ireland and Greece-Portugal cases do the trace test indicate the existence of one cointegrating equation at (at least) the 0.05 level. Therefore, for these two pairs we test for Granger-causality in first differences of the variables, with an error-correction term added [i. e., equations (3) and (4)], whereas for the remaining cases, we test for Granger-

[12] Recall that the number of possible pairs between our sample of five peripheral EMU yields is given by the following formula $\frac{n!}{r!(n-r)!}=\frac{5!}{2!(5-2)!}=10.$

causality in first differences of the variables, with no error-correction term added [i. e., equations (3) and (4) with $\beta=0$]

[Insert Table 4 here]

2.4. Empirical results

The resulting FPE statistics for the whole sample are reported in Table 5.[13]

[Insert Table 5 here]

As can be seen, in most of the cases our results suggest bidirectional Granger-causality. We do not find unidirectional Granger-causality relationships running from Greece to Spain or from Portugal to Ireland.

Note that, even though the results of the cointegration tests reject (with only two exceptions) a long-run relationship between them, we find evidence of strong Granger-causal linkages between peripheral EMU yields. Therefore, each yield series contains useful information that is not present in the others which can help to explain the others' short-run evolution.

In order to gain further insights into the dynamic Granger-causality between the 10 possible relationships in peripheral EMU yields, we carry out 33,486 rolling regressions using a window of 200 observations[14]. In each estimation, we apply Hsiao (1981)'s sequential procedure outlined above to determine the optimum FPE (m, 0) and FPE (m, n) statistics in each case.

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[13] These results were confirmed using both Wald statistics to test the joint hypothesis $\hat{\gamma}_1 = \hat{\gamma}_2 = \ldots = \hat{\gamma}_n = 0$ in equation (4) and Williams-Kloot test for forecasting accuracy (Williams, 1959). These additional results are not shown here to save space, but they are available from the authors upon request.

[14] To the best of our knowledge, there is no statistical method to set the optimal window size. The chosen value of 200 observations is representative of the one used in practice and seems appropriate for our empirical application since it represents 6.36% of the sample. We have also used a value of 100 observations. The results (not shown here to save space, but they are available from the authors upon request.) render the same qualitative conclusions than in the case of using 200 observations.

A graphic presentation of the evolution of the difference between FPE (m, 0) and FPE (m, n) statistics in each case is shown in Figure 2. These graphs provide us with a view of the dynamic influence of each EMU peripheral yield over the other four and constitute our indicator of time-varying Granger-causality. Adopting a forward-looking framework, we assign the computed indicator to the first date used in the rolling regressions. Therefore, the sample covers the period 1 January 1999 to 26 March 2010 in all cases, except in those pairs where Greece is present, in which case the sample runs from 1 January 2001 to 26 March 2010. Note that if the difference is positive in the case XX → YY, this indicates the existence of a statistically significant Granger-causality relationship running from country XX towards country YY.

As can be seen, we find sub-periods of Granger-causality in all pair-wise relationships, including those running from Greece to Spain and from Portugal to Ireland, even though these relationships were rejected in the whole sample tests. In other words, we detect, in all cases, sub-periods where the yields on bonds issued by one peripheral EMU country carries relevant and useful information about the future behaviour of the yields on bonds issued by other peripheral EMU country.

We proceed further by identifying sub-periods of significant increase in Granger-causality in order to be able to analyze which factors may have been behind them. To that aim, we identify episodes of Granger-causality intensification as those in which the time-varying Granger-causality indicator is greater than its average plus two standard errors[15]. Therefore, we look for episodes where there is evidence of an enlargement in the information content of the yield series to significantly improve the explanatory power of future evolution of the other yield series, suggesting a strengthening of their interdependence.

The graphs in Figure 2 suggest that these episodes are concentrated around the first year of the existence of the EMU in 1999, the introduction of euro coins and banknotes in 2002, and the

[15] We perform formal tests to evaluate whether the series have the same mean during the detected episodes and the rest of the observations. The results of these tests (not shown here, but available from the authors upon request) strongly reject the null hypothesis of equal mean across sub-samples, and provide additional support for the presence of increased Granger-causality.

global financial crisis of the late-2000s. As can be seen, the graphs also indicate that the Granger-causality relationships between peripheral EMU yields increased significantly during the recent crises in sovereign debt markets since 2009, providing evidence of a reinforcement of the interconnection between them.

[Insert Figure 2 here]

3. Determinants of episodes of Granger-causality intensification

3.1. Econometric methodology

Once the episodes of Granger-causality intensification have been detected, we use Probit models to analyze their determinants. In our case, we define a new dependent variable (*y*) that takes the value one if we have detected such episode and zero otherwise. The goal is to quantify the relationship between a set of instruments (*X*) characterizing the country issuing a given bond and the probability of an episode of increased causality (*y*).

To this end, we adopt a specification designed to handle the particular requirements of binary dependent variables. Suppose that we model the probability of observing a value of one as:

$$\Pr\,(y = 1 \mid X, \beta) = 1 - \Phi\,(-X'\beta) = \Phi\,(X'\beta) \qquad (5)$$

where Φ is the cumulative distribution function of the standard normal distribution. As can be seen, we adopt the standard simplifying convention of assuming that the index specification is linear in the parameters so that it takes the form $X'\beta$.

3.2. Instruments to model the Granger-causality intensification

According to Dornbusch, Park, and Claessens (2000), reasons that may explain the evolution of yield's Granger-causality between countries can be divided into two groups: fundamental-based reasons on the one hand, and investor behavior-based reasons on the other. While fundamental-based transmission works through real and financial linkages across countries, behavior-based is more sentiment-driven. Therefore, in our analysis we will use instruments that capture both of them. Following the literature, in order to measure fundamental reasons, we not only use instruments that gauge each country's component of risk, but also instruments that asses global risk. To that end, on the one hand, we use instruments that capture the country's fiscal position, the foreign debt, the country's potential rate of growth, the loss of competitiveness, the private sector indebtedness and, especially the cross-border banking system linkages. And on the other hand, we use indicators of global illiquidity and risk.

Concretely, the variables used to measure the country's fiscal position are the government debt-to-GDP (GOVDEB) and the government deficit-to-GDP (DEF). These two variables have been widely used in the literature by other authors (see, e.g., Bayoumi *et al.*, 1995) and present the advantage over the credit rating that they cannot be considered *ex post* measures of fiscal sustainability. They are compiled from Eurostat, and monthly data are linearly interpolated from quarterly observations. Besides, the current-account-balance-to-GDP ratio (CAC) is the instrument used as a proxy of the foreign debt and the net position of the country towards the rest of the world. The importance of this variable has been underlined by the IMF (2010) and Barrios *et al.* (2009). This variable is drawn from the OECD and monthly data are linearly interpolated from quarterly observations. In view of Mody (2009)'s argument that countries' sensitivity to the financial crisis is more pronounced the greater the loss of growth potential and competitiveness, we include instruments that measure these features. The unemployment rate (U), which has been collected from Eurostat, is the variable used to capture the country's growth potential, whilst the Harmonized Index of Consumer Prices monthly interannual rate of growth (which has also been drawn from Eurostat) is the inflation rate measure (INF) we use as a proxy of the appreciation of the real exchange rate and, thus, the country's loss of competitiveness.

To assess the interconnection between the public and private debt and the role of the latter in the euro area sovereign debt crisis, we also incorporate instruments that capture the level of indebtedness of each country's private sector in the analysis. To that end, we make use of a unique dataset on private debt-to-GDP by sector (households, banks and non-financial corporations) in each EMU country. In particular, we use three variables: Banks' debt-to-GDP (BANDEB), non-financial corporations' debt-to-GDP (NFIDEB), and households' debt-to-GDP (HOUDEB), which have been constructed from data obtained from the European Central Bank Statistics. A summary of their evolution is presented in Table 6. Concretely, we have used the statistics corresponding to the Monetary Financial Institutions (MFI) balance sheets in each euro country. Thus, household debt corresponds to the total loans to households from MFIs. To isolate it from the intermediation effect that would inflate debt ratios, banks' debt is constructed by subtracting M3, banks' remaining liabilities and banks' capital and reserves from total MFI liabilities[16]. And non-financial corporation debt is built up by adding non-financial corporation securities to total loans to non-financial corporations from MFIs[17].

[Insert Table 6 here]

Table 6 clearly shows the importance of private debt in the ongoing crisis. Concretely, after the subprime crisis in August 2007, not only does the government level of indebtedness increase in the euro area (the ratio over the GDP achieves levels of 143%, 119%, 96%, 93% and 60% at the end of December 2010 in Greece, Italy, Ireland, Portugal and Spain, respectively) but private borrowing also registers a sizeable increase. In particular, as can be observed, at the end of 2010, banks' debt-to-GDP is huge in Ireland (729%), but is also high in Portugal, Spain and Greece (182%, 159% and 98%). On the other hand, households' debt-to-GDP surpasses the 80% threshold in Ireland, Portugal and Spain, whilst non-financial corporations' debt-to-GDP is close to 90% in Portugal and Spain and around 70% in Ireland. Thus, during the period 2007-2010, whereas the government debt-to-GDP ratio registers the highest increases compared to the period 2002-2006 in Ireland, Portugal and Greece (39%, 15% and 9%), there is a much steeper rise in the banks' debt-to-GDP ratio which is higher than 150% in Greece, close to 70% in Ireland, around 64% in Spain and close

[16] The banks' debt variable we have constructed avoids the effects of intermediation, even though it can only be considered as an approximation of its real value, and some caveats are in order: specifically, some deposits will appear as debt (those not included in M3) and some debt securities will not be considered debt (those included in M3).

[17] Non-financial corporations' (NFCs) debt should also include "net equity of households" (liabilities of NFCs from direct pension commitments to their employees). Nevertheless, we have ignored this variable since it was not available for all the countries in the sample.

to 40% in Portugal. Besides, households' debt-to-GDP ratio registers an increase close to 30% in Greece, close to 20% in Ireland and Spain and around 15% in Italy, whilst non-financial corporations' debt-to-GDP ratio rises close to 30%, 25% and 20% in Ireland, Spain and Greece respectively.

As it has already been mentioned, some authors (Bolton and Jeanne (2011) and Allen *et al.* (2011) among them) outline that, in an scenario of increased international financial activity in the euro area, not only public finances imbalances are key determinants of the probability that the sovereign debt crisis could spill over from one country to another, but that transmission of the crisis through the banking system can also be a major issue. Therefore, in our analysis we also include variables that capture the important cross-border banking system linkages in euro area countries. These linkages are measured using the consolidated claims on an immediate borrower basis of Bank for International Settlements (BIS) reporting banks in the public, banking and non-financial private sectors as a proportion of GDP (monthly data are linearly interpolated from quarterly observations). In particular, we include foreign bank claims on government debt-to-GDP (PUB), on bank debt-to-GDP (BAN) and on non-financial private sector debt-to-GDP (PRI). The evolution of these variables is summarized in Table 7.

[Insert Table 7 here]

The figures in Table 7 underline the fact that, as it was mentioned in the Introduction, the causes of the debt crises that led to subsequent rescues in Europe varied substantially according to country. Greek fiscal deficit and public debt to GDP were close to 15% and 130% at the end of 2009 as a result of chronic macroeconomic imbalances. Besides, on average, foreign banks' claims on its public sector debt represented around 30% of its GDP during the period 2005-2010. Conversely, in Ireland, the crisis was mainly due to the private sector, particularly the domestic housing boom which was financed by foreign borrowing. In particular, the amount of bank and non-financial enterprise debt claimed by foreign banks is huge during the period 2005-2010 (102% and 216% of its GDP, on average). Finally, in Portugal, markets were mostly worried about the country's high external debt, specifically, that of its non-financial corporations. During the 2005-2010 period, foreign banks' claims on Portuguese enterprises surpassed 40% of the country's GDP.

Moreover, we also explore the role of consolidated claims on an immediate borrower basis provided by BIS by nationality of reporting banks as a proportion of total foreign claims on each country. This variable is denoted as XXYYBAN, meaning the percentage of country XX's foreign claims held by country YY's banks (again, monthly data have been linearly interpolated from quarterly observations).

[Insert Table 8 here]

This information is displayed in Table 8 and is very useful for understanding the channels of transmission of debt crises through the banking system. It can be observed that at the end of 2010 French and German banks were the most exposed to foreign Greek debt, holding 39.6% and 23.7% of total foreign Greek claims respectively. In the case of Ireland, the maximum risk was borne by British banks (29.9%) followed by the Germans (26.13%). A Portuguese default would be especially harmful for Spanish banks which hold 41.9% of Portuguese banks' total claims. Finally, around 45% and close to 65% of Spanish and Italian foreign claims, respectively, are held by French and German banks.

As mentioned, we also introduce an instrument that might capture investor behavior-based reasons of crisis's transmission. We use the credit rating as a proxy of the default risk (RAT). Standard &Poor's, Moody's and Fitch ratings for each government's debt are compiled from Bloomberg. Following Blanco (2001), we build up a scale to gauge the effect of investor sentiment based on the rating offered by the three agencies[18].

[18] By construction, the higher the scale, the worse the rating categories.

Finally, two additional potential determinants have also been considered to analyze the evolution of yield's Granger-causality intensification between countries: liquidity and global risk aversion[19].

Financial market liquidity is generally defined as the ease of trading in assets compared to trading in money, thus reflecting the cost of converting a financial asset into money. Since trading implies a cost to those conducting the transaction, this notion of liquidity also embodies the ability of financial markets to absorb large transactions in securities without any significant effect on prices. There are a bunch of papers that provide evidence for a significant effect of (il)liquidity on sovereign bond yields, among which are Barrios et al. (2009), Gerlach *et al.* (2010), Gomez-Puig (2006), Beber *et al.* (2009), Pagano and von Thadden (2004). Even though, the empirical evidence for the existence of a liquidity premium in bond yields is mixed. In this paper, we account for global financial market illiquidity (ILLIQUIDITY), since it might explain simultaneous behavior of peripheral sovereign yields and, therefore, affect causality between them. To that end, we use an "illiquidity ratio" (ILR) which has been provided by the European Central Bank. In its basic version, the ILR captures the extent to which the price of a certain security changes for each volume unit of trades, and can therefore be characterized as an elasticity measure. As its name suggests, the ILR attempts to quantify the lack of liquidity in the market, so that a high ILR estimate indicates low liquidity since it reflects a high price impact conditional on the trading volume. To generalize the concept in order that if could serve as a measure of global liquidity, a large number of individual equity firm data on prices and volumes are aggregated into an indicator for advanced economies (see European Central Bank, 2012a).

Moreover, several studies show that sovereign bond yields are not only driven by country-specific risk factors but that they are also significantly affected by global risk factors (see Codogno *et al.* (2003), Sgherri and Zoli (2009), Bernoth and Erdogan (2012) among them). These global risk factors reflect global investors' risk aversion, since in times of uncertainty, they become more risk

[19] We are very grateful to an anonymous referee for suggesting us these additional determinant factors.

averse and the "flight-to-safety" motive favors bonds of countries that are generally regarded to have a low default risk. Therefore, an increase in the Granger-causality of bond yields might also reflect a general increase in investors' risk aversion which might drive the yields of the peripheral countries simultaneously. To measure risk aversion in financial markets, we rely on the Chicago Board Options Exchange Market Volatility Index (VIX), used by Bloom (2009) to capture uncertainty[20] (this variable is denoted as RISK).

Besides, the interaction effects between the global risk indicator and the illiquidity ratio (denoted as ILLIQUIDITY *RISK) and between the global risk indicator and both public and private debt-to-GDP by sector have also been tested (denoted as XXYYYDEB*RISK, where YYY = GOV, BAN, NFI or HOU, depending if we are using Government, Bank, Non-financial corporations or Households debt-to-GDP of country XX) have also been assessed.

Appendix 1 offers a summary of the explanatory variables used in the empirical analysis as well as the data sources.

3.3. Empirical results

3.3.1 Basic model

Given that the instruments used as independent variables have been constructed on a monthly frequency, we need also to compute the dependent variable in the Probit models on a monthly basis. To do so, we first assign a value of 1 to the daily observation if the time-varying Granger-causality indicator is greater than its average plus two standard errors. In the second step, we compute the monthly data by averaging the daily observation and assigning a value of 1 if the resulting monthly average is greater than 0.5 (i. e., if at least for half of the month there is evidence of Granger-causality intensification).

[20] The VIX represents the option-implied expected volatility on the S&P500 index with a horizon of 30 calendar days. In the empirical analysis, we use end-of-month VIX levels. As pointed out by Bekaert *et al.* (2012), the link of VIX to option prices means it also harbours information about risk and risk aversion.

We follow the general to specific approach characteristic of the London School of Economics based on the theory of reduction (Hendry, 1995, ch. 9). Therefore, our empirical analysis starts with a general statistical model that captures the essential characteristics of the underlying dataset, reducing the complexity of this general model by eliminating statistically insignificant variables, checking the validity of the reductions at every stage to ensure congruence of the finally selected model. In Table 9 we report the final results of the Probit models estimated by maximum likelihood for the sample period March 2005 to March 2010[21,22,23]. The z-statistics in that table are based on robust standard errors computed using the Huber-White quasi-maximum likelihood method.

[Insert Table 9 here]

The analysis of the coefficient values is complicated by the fact that coefficients estimated from a binary model cannot be interpreted as the marginal effect on the dependent variable. Nevertheless, the direction of the effect of a change in any instrument depends only on the sign of the coefficient estimated: positive values imply that an increase in a given instrument will raise the probability of an increase in Granger causality, while negative values indicate the opposite. To gain further insights in the influence of the explanatory variables, we also show in Table 9 the marginal effects to compare their relative impacts. These marginal effects measure the influence of a unit change in a given explanatory variable on the probability of pair-wise Granger-causality intensification, holding all the other variables constant, and have been computed at their average values. We first present the main

[21] Note that even though we could be dealing with a binary choice model with I(1) regressors, Park and Phillips (2000) have proved that the coefficient estimated by maximum likelihood are still consistent, converging at a rate $T^{3/4}$ along its principal component, having a slower rate of T^{314} convergence in all other directions. Moreover, this authors showed that the limit distribution of the maximum likelihood estimator was mixed normal with mixing variates being dependent upon Brownian local time as well as Brownian motion, so the usual inference methods are still valid Grabowski (2007) have added that when among the regressors include variables with different orders of integration, the rate of convergence of the estimate of the coefficients depend of such order: T^{314} for stationary regressors and T^{314} for I(1) or I(2) regressors.

[22] The reduction in the sample period is imposed by the availability of data regarding the consolidated claims of Bank for International Settlements' reporting banks on each sector.

[23] The results are very similar for Logit models run on the same data.

conclusions from the analysis of significance of the dependent variables in the different models and afterwards we will focus on their marginal effect

As expected, our results indicate that the variables used to measure the country's fiscal position (GOVDEB and DEF) are important determinants of the probability of an episode of Granger-causality's increase. However, our results also indicate that other factors beyond the fiscal position explain those episodes, too. Notably, three variables are statistically significant in all cases: XXYYBAN, ILLIQUIDITY and RISK.

The significance of XXYYBAN suggests that, in a scenario of increased cross-border financial activity in the euro area, transmission of the crisis in one country to other countries through the banking system can really be a major issue.

On the other hand, the finding of a significant and negative sign for the variable ILLIQUIDITY could be suggesting that, as expected, crisis transmission increases with the degree of liquidity in financial markets[24]; whilst the significance of the variable RISK could be interpreted as evidence supporting the view that an increase in investors' risk aversion favors transmission of the crisis since the "flight-to-safety" motive benefits bonds of countries that are generally regarded to have a low default risk.

Moreover, the instruments used to gauge both the level of competitiveness (INF) and the net position towards the rest of the world (CAC) are statistically significant with the expected sign[25]. In particular, they are extremely useful when explaining the Granger-causality from Greece, Spain and Portugal. In relation to the variables used to capture the country's growth potential, we find a positive influence for the unemployment rate, which suggests that the weaker the economy, the

[24] Using the liquidity indicators proposed by Pastor and Stambaugh (2003), we obtain qualitative similar results, although with the opposite sign.

[25] Note that CAC is defined as the difference between exports and imports. Therefore an increase in CAC would signal an improvement in the net position of the country towards the rest of the world, reducing the probability of Granger-causality intensification in pair-wise relationships.

higher the probability of sovereign debt crisis transmission. This conclusion is particularly relevant in the case of Greece, Spain, Portugal and Italy.

With regard to the role of private debt, we find empirical evidence supporting its importance in the cases of Spain, Italy and Ireland. Household's debt and non-financial-corporations' debt are useful variables to explain transmission of the crisis from Italy and Spain, respectively; whilst bank's debt explains Granger-causality intensification from the two mentioned countries[26]. On the other hand, foreign banks' claims on banks debt-to-GDP, are very helpful to explain the probability of an episode of Granger-causality's increase from Ireland.

These results are very relevant in the Spanish and Irish case since they support what we have mentioned in the Introduction regarding the different causes of the debt crises in Europe according to the country. In Spain, the resort to financing was not led by the public sector but, precisely, by private households and firms. The ratio of non-financial corporations' debt-to-GDP was close to 90% at the end of 2010 in this country (see Table 6). Therefore, the results support an important role of private debt, specifically, that hold by non-financial corporations, in the transmission of the crisis from Spain.

In the Irish case, the crisis was also mainly due to the private sector, particularly a domestic housing boom which that was financed by foreign borrowers who did not require a risk premium related to the probability of default (foreign banks' claims on banks debt-to-GDP were 101,51% on average during the period 2005-2010, see Table 7). Our results also support this idea since they detect a major effect of foreign banks' claims on banks debt-to-GDP on the probability of an episode of Granger-causality's increase from Ireland.

[26] The finding of a significant role of bank's debt as determinant of Granger-causality intensification could be related to the transfer of risk from the banking sector to the public sector, since many governments were called on to support their banking system through direct capital injections and indirect balance-sheet support in the form of guarantees.

The results concerning the influence of investor sentiment indicate that the credit rating scale seems to be an important determinant in eleven out of the 20 cases considered.

As can be seen in Table 9, the larger marginal effects are associated with the variable XXYYBAN. Particularly, in the cases of the bidirectional interactions of Greece and Ireland and the unidirectional Granger-causality relationships running from Spain to Greece, Portugal to Spain, Portugal to Ireland, Spain to Ireland and Portugal to Italy. It can also be observed that instruments that gauge local risk present larger marginal effects that those that capture global risk (both risk aversion and illiquidity) reinforcing the relative importance of country components of risk versus other factors in explaining the probability of an episode of Granger-causality's increase. Concretely, the marginal effect of the unemployment rate (U), that has been used to capture the country's growth potential, is especially large in the Granger-causality relationships running from Portugal, Spain, Ireland and Italy. The marginal effect of the current-account-to-GDP-ratio (CAC), the instrument used as a proxy of the foreign debt and the net position of the country towards the rest of the word, is especially high in the relationships running from Spain and Ireland (two countries where domestic expansion was financed by external debt); whilst the marginal effect of the government-deficit-to-GDP (DEF) is particularly large in the relationships running from Portugal (we should recall that in contrast to Ireland and Spain, the origin of the debt crisis in Greece and Portugal was the structural deficit in the government sector). Finally, our results also support the idea presented by Dornbush, Park and Claessens (2000) according to which, reasons that may explain the evolution of yield's Granger-causality between countries can be divided into two groups: fundamental-based reasons on the one hand, and investor behavior-based reasons on the other. In this sense, not only the instrument that measures investor sentiment (RAT) is statistically significant in eleven out of the 20 cases considered but its marginal effect is particularly large in the case of the relationship running from Italy to Spain.

Finally, in Table 9 we report the McFadden R-squared as a measure of goodness of the fit. As can be seen, it ranges from 0.6557 to 0.8977, suggesting the relative success of the Probit regression models in predicting the values of the dependent variable within the sample[27]. As a further test to evaluate how well our estimated Probit models fit the observations, we compute the fitted probability both within-sample and out-of-sample. Recall that when generating our indicator, we left out nine observations (April to December 2010) that were not used in the estimation. This allows us to evaluate the out-of-sample performance of the estimated Probit models based on the actual evolution of the instrumental variables. Figure 3 reports the results.

[Insert Figure 3 here]

As can be seen, the fitted probabilities closely track the evolution of the observed within-sample probabilities. Regarding the out-of-sample probabilities, our results suggest the occurrence of an additional episode of significant increase of Granger-causality in the last months of 2010 coinciding with a period of renewed turbulence in European debt markets.

3.3.2 Model refinements[28]

The previous Probit model can be refined by allowing for the interaction effect between the explanatory variables. In particular, we examine the interaction effects of illiquidity and global risk aversion and of debt and global risk aversion. In the first case, from the last subsection we concluded that, individually, illiquidity has a negative impact and global risk aversion has a positive impact on the probability of a Granger-causality intensification in the bilateral relationships of peripheral EMU public debt markets. To assess the combined influence of illiquidity and risk aversion on the probability of such Granger-causality intensification, we introduce a multiplicative or interactive effect of the two variables as an additional explanatory variable. The results are given in Table 10. As for the case of debt and global risk aversion, we have previously found that individually both variables have a positive impact on the probability of a Granger-causality intensification and, to evaluate the interplay between them, we add an interactive effect of the two variables in the basic Probit model. The results are reported in Table 11, where there are not results

[27] The same conclusion is reached when performing the Pearson-type test of goodness-of-fit proposed by Hosmer and Lemeshow (2000.)

[28] We are very grateful to an anonymous referee for suggesting us these model refinements.

for the cases of IRELAND→GREECE and IRELAND→ITALY since no debt variable was found significant in the estimation of the basic Probit model.

As can be seen from Table 10, the interaction effects of illiquidity and global risk aversion have always a highly significant negative impact on the Probit, suggesting that the effect of an increase in global risk aversion on the probability of Granger-causality intensification in pair-wise relationships is attenuated if there is a tightening of financial market liquidity conditions. This result is in line with Favero *et al.* (2010)'s hypothesis that the equilibrium value of liquidity tends to be lower in worse aggregate states.

Regarding the interaction of debt and global risk aversion, we always obtain both a positive and significant impact on the Probit and an increase in the individual marginal effect of the debt indicators, suggesting that the incidence of an increase in Government, Bank, Non-financial corporations or Households debt on the probability of Granger-causality intensification in peripheral EMU sovereign yields behavior is magnified in a context of high global risk aversion.

Taken together, the results from both interaction exercises could be suggesting that in an environment of abundant liquidity and high risk appetite, sovereign yields in these countries did not fully reflect differences in macroeconomic fundamentals, but when the overall global liquidity was reduced, the role of the underlying weaknesses was exacerbated, leading to a more closed interconnection among them.

4. Concluding remarks

In the current context of uncertainty in European sovereign debt markets, the analysis presented in this paper deals with a subject that has not been addressed in sufficient depth by the literature and is of particular relevance both to academics and to policy-makers.

Concretely, this paper presents a dynamic approach to the analysis of the evolution of the degree of Granger-causality between peripheral EMU sovereign yields behavior (Greece, Ireland, Italy, Portugal and Spain). To this end, we have (1) tested for the existence of possible Granger-causal relationships between the evolution of these countries' ten-year yields, (2) examined the time-varying nature of these Granger-causal relationships to detect episodes of significant increase of causality between them, and (3) analyzed the determinants of these episodes.

Since it seems increasingly clear that the origin of sovereign debt crisis in Europe has gone beyond the imbalances in public finances and that there is an obvious interconnection between public and private debt, we have analyzed the role of the latter in the episodes of Granger-causality intensification by using a unique dataset on private debt-to-GDP by sector (households, banks and non-financial corporations) in each peripheral EMU country. Besides, since the reasons that may explain transmission of sovereign debt crisis from one country to another can be fundamental-based or investor behavior-based, we have included instruments that capture both types. In addition, we have borne in mind that fundamental-based interconnection works not only through real linkages, but also through financial linkages across countries. Specifically, in the current scenario of increased cross-border financial activity in the euro area, special attention has been paid to the impact of the degree of integration of the banking system on the speed at which a sovereign crisis in a country can spill over to others. This channel of transmission has generally been ignored by the recent literature, but its relevance is crucial.

The main results of our analysis can be summarized as follows. Firstly, the results of the rolling analysis we apply in order to explore the dynamic causality between peripheral EMU yields suggest that there exist sub-periods of Granger-causality in all pair-wise relationships. Secondly, our empirical evidence suggests that the episodes with significant Granger-causality increase are concentrated around the first year of the launch of the EMU in 1999, the introduction of euro coins and banknotes in 2002 and, specially, the global financial crisis in the late-2000s. Therefore, our results indicate that the Granger-causality relationships between peripheral EMU yields have been significantly reinforced during the recent crises in sovereign debt markets since 2009. Thirdly, the results of the Probit models estimated to analyze the determinants of the previously detected episodes indicate that in all cases the variable that captures cross-border banking linkages is statistically significant. This finding suggests that, in a scenario of increased international financial activity in the euro area, transmission of the crisis in one country to other countries through the banking system may be an important issue (this is explained by the "financial trilemma" laid out by Schoenmaker, 2011). It is important to recall that macroeconomic imbalances in a specific country (the instruments we have used to capture them also indicate that they are key determinants of the probability of occurrence of an episode of Granger-causality's increase) lead to rising sovereign spreads and a devaluation of the government debt that is mirrored in banks' balance sheets. Moreover, regarding the role of private debt, we find evidence of its relevance in the cases of Italy, Spain and Ireland. Its significance in the Spanish and Irish case is very important since it was the private sector the main cause of the debt crisis in these two countries. Lastly, the consideration of the interaction effects of illiquidity and global risk aversion and of debt and global risk aversion indicates that abundant liquidity could have undermined market discipline, which could otherwise have become an important pillar of macroeconomic and fiscal discipline in the euro area.

Therefore, our results suggest that euro area crisis faces multiple overlapping and mutually reinforcing elements of fiscal (Greece and Portugal), banking (Ireland and Spain), and competitiveness (Southern periphery) crises. This situation has lead many authors (see, for example, Bergsten and Kirkegaard, 2012) to state that the euro area is foremost facing a crisis of "institutional design". Indeed, the euro crisis is now in its third year and there is still no end in sight. The main reason for this situation is that some of its root causes have been left largely unattended. In particular, no mechanism has been put in place to address the feedback loop between sovereigns and banks that our results have shown. In this context, Pisani-Ferry (2011) lays out that the euro was imagined in the late 1980s in response to what was known as Mundell's trilemma, according to which no country can enjoy at the same time free capital flows, stable exchange rates and independent monetary policies. Twenty years later, the euro area faces another trilemma that stems from three of the basic principles upon which the European currency is based: the absence of co-responsibility over public debt, the strict no-monetary financing rule and the combination of free capital movements and national responsibility for supervising and, if needed, rescuing banking systems. The coexistence of these three principles makes the euro area fragile, for two reasons. First, adverse shocks to sovereign solvency tend to interact perversely with adverse shocks to bank solvency. Second, the central bank is constrained in its ability to stem self-fulfilling debt crises. Therefore, now as twenty years ago, the question is which of the constraints the euro area should give in. The problem is that putting in place the necessary mechanism to solve the trilemma would involve transforming the euro area into a full-fledged monetary union with a fiscal and banking union. In turn, this would require agreement on sharing sovereignty, mutualising risk and creating European-level accountability channels that would amount to creating a political union. Although nothing short of such political union might ultimately be sufficient to ensure the long term viability of the monetary union, it is equally clear that it will take significant time to achieve even under the most optimistic assumptions.

At this juncture, however, what appears more feasible and some of the short run policy implications that we suggest in this paper to fight this crisis are the following. The euro area would need (a) to take a decisive step forward by creating a banking union (see, for example, Pisani-Ferry et *al.*, 2012, or Schoenmaker and Gros, 2012) and/or (b) to issue jointly guaranteed Eurobonds (see Favero and Missale, 2011, Delpla and von Weizsacker, 2010, 2011, or Claessens et *al.*, 2012, among others).

Schoenmaker and Gros (2012) claim that the European Commission and the EU Council are still seeking solutions at the national level, whilst the financial trilemma (Schoenmaker, 2011) shows that policymakers have to choose 2 out of 3 objectives: 1) financial stability, 2) cross-border banking or 3) national policies. In the context of this trilemma, these authors assert that the best policy option would be to take the financial trilemma to its logical conclusion and move powers for financial policies (regulation, supervision and stability) further to the European level, since a European banking policy is needed to preserve cross-border banking as well as financial stability. Indeed, the ECB is supporting this call for a European banking policy in its latest Financial Integration Report (see, European Central Bank, 2012b).

On the other hand, the idea that Eurobonds could offer relief to Member States with weak fiscal fundamentals, like Italy and Spain, and help solve the euro-area debt crisis has also emerged in both the policy and academic debate. The most forceful argument against a jointly guaranteed Eurobond (see, for example, Issing, 2009) is that it would undermine fiscal discipline by removing incentives for sound budgetary policies and that the cross-default nature of the joint guarantees would undermine the no bailout clause of the EU Treaty (heightening the risk of moral hazard). However, advocates of Eurobonds as Delpla and von Weizsacker (2010, 2011) and Claessens et *al.* (2012) contend that the use of Eurobonds should not only be limited but also conditional on the implementation of fiscal adjustment and reforms. Moreover, some authors (Favero and Missale, 2011, among them) have argued that to the extent that market irrationality and contagion play a greater role than fiscal fundamentals in the pricing of risk, a common Eurobond could be a useful instrument to halt the crisis transmission.

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Appendix 1: Definition of the Explanatory Variables in the Probit models and Data Sources

NAME	VARIABLE	SOURCE
CACXX	Current-account-balance-to-GDP of country XX	OECD (monthly data are linearly interpolated from quarterly observations)
UXX	Unemployment rate of country XX	Eurostat (monthly data)
INFXX	Inflation rate of country XX	Eurostat (HICP monthly interannual rate of growth)
RATXX	Credit rating scale of country XX.	Bloomberg: Standard &Poor's, Moody's and Fitch ratings for each government's debt.
DEFXX	Government deficit-to-GDP of country XX.	Eurostat (monthly data are linearly interpolated from quarterly observations)
ILLIQUIDITY	Financial market illiquidity ratio for advanced economies	European Central Bank, Monthly Bulletin, October 2012, Chart 5, p.63
VIX	Chicago Board Options Exchange Market Volatility Index	Chicago Board Options Exchange
XXGOVDEB	Government debt-to-GDP of country XX.	Eurostat (monthly data are linearly interpolated from quarterly observations)
XXBANDEB	Banks' debt-to-GDP of country XX	ECB's Monetary Financial Institutions balance sheets and own estimates (monthly data). GDP has been obtained from Eurostat (monthly data are linearly interpolated from quarterly observations)
XXNFIDEB	Non-financial corporations' debt-to-GDP of country XX	ECB's Monetary Financial Institutions balance sheets and own estimates (monthly data). GDP has been obtained from Eurostat (monthly data are linearly interpolated from quarterly observations)
XXHOUDEB	Households' debt-to-GDP of country XX	ECB's Monetary Financial Institutions balance sheets and own estimates (monthly data). GDP has been obtained from Eurostat (monthly data are linearly interpolated from quarterly observations)
XXBAN	Foreign bank claims on banks debt-to-GDP of country XX	BIS Quarterly Review: June 2011, Table 7C. GDP has been obtained from the OECD (monthly data are linearly interpolated from quarterly observations)
XXPUB	Foreign bank claims on government debt-to-GDP of country XX	BIS Quarterly Review: June 2011, Table 7C. GDP has been obtained from the OECD (monthly data are linearly interpolated from quarterly observations)
XXPRI	Foreign bank claims on non-financial private debt-to-GDP of country XX	BIS Quarterly Review: June 2011, Table 7C. GDP has been obtained from the OECD (monthly data are linearly interpolated from quarterly observations)
XXYYBAN	Percentage of country XX's foreign claims held by country YY's banks	BIS Quarterly Review: June 2011, Table 9D and own estimates.

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Figure 1a. Daily 10-year sovereign yields in peripheral EMU countries: 1999-2010

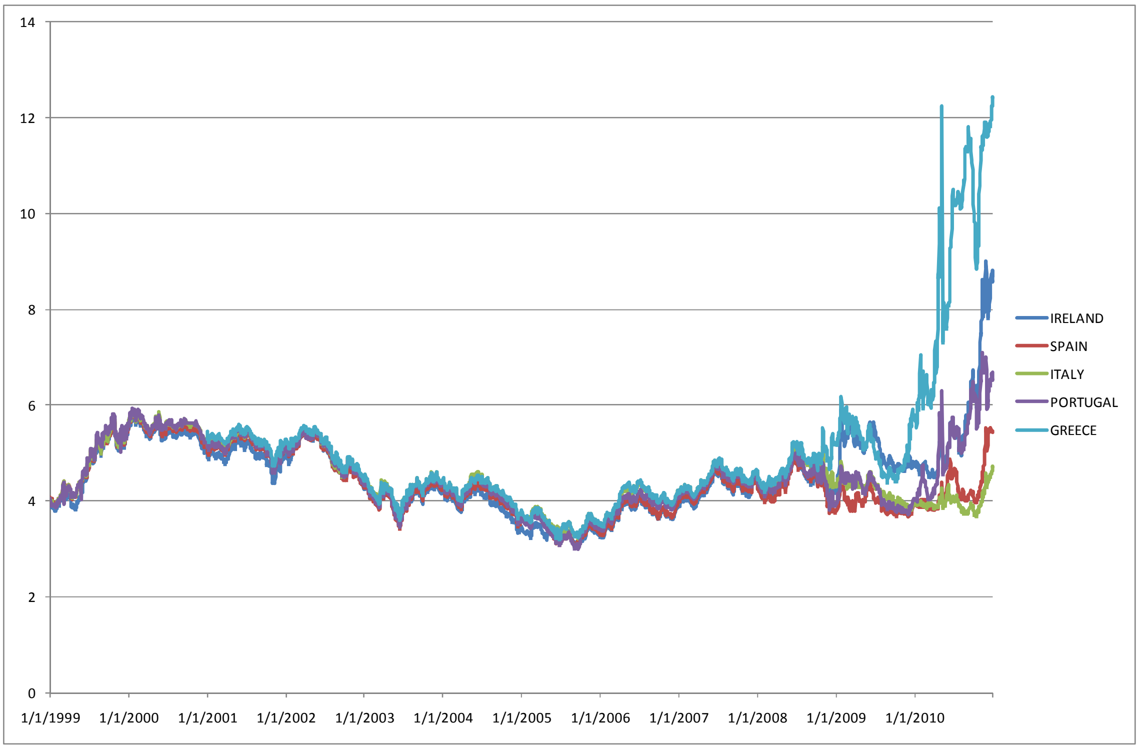


Figure 1b. Daily 10-year sovereign yield spreads over Germany: 1999-2010

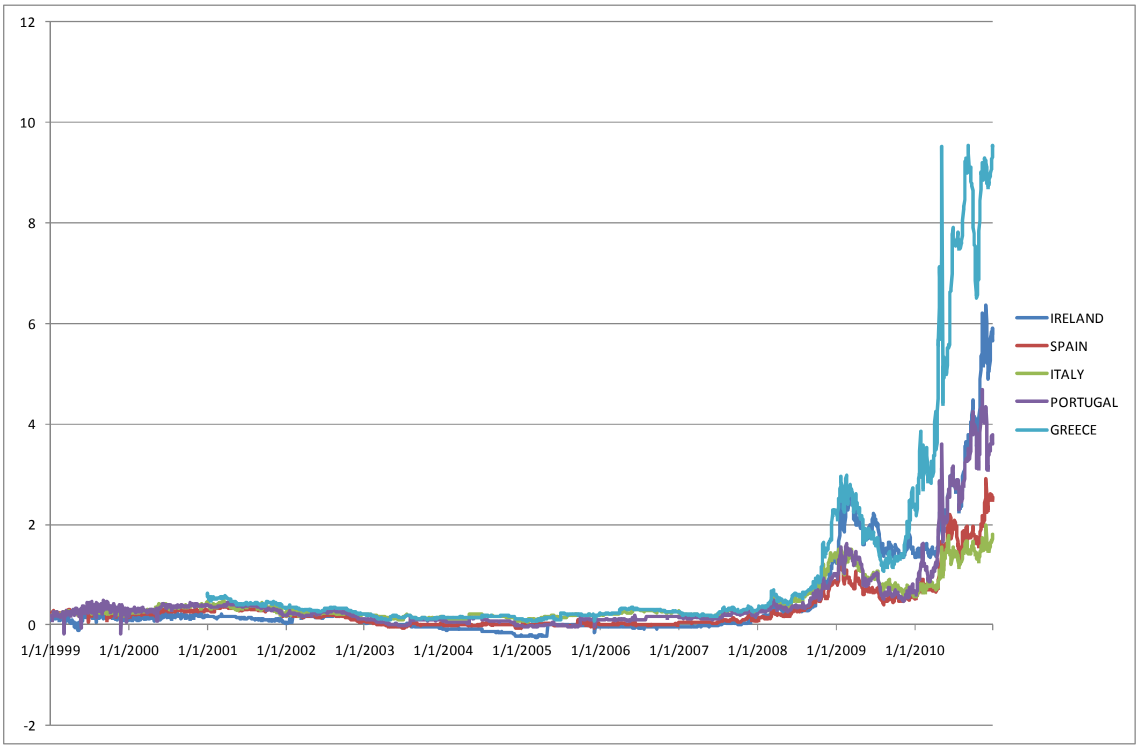
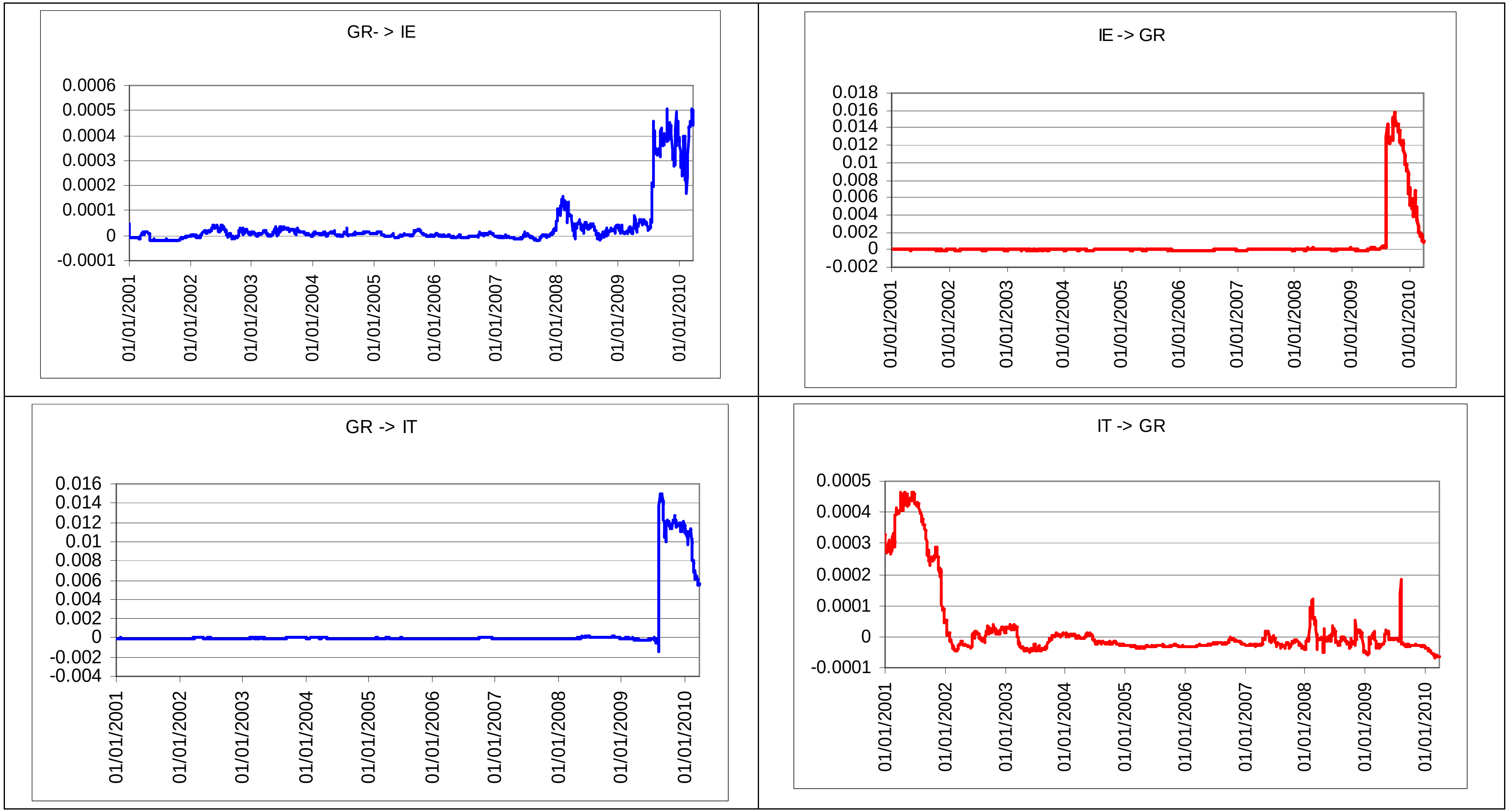
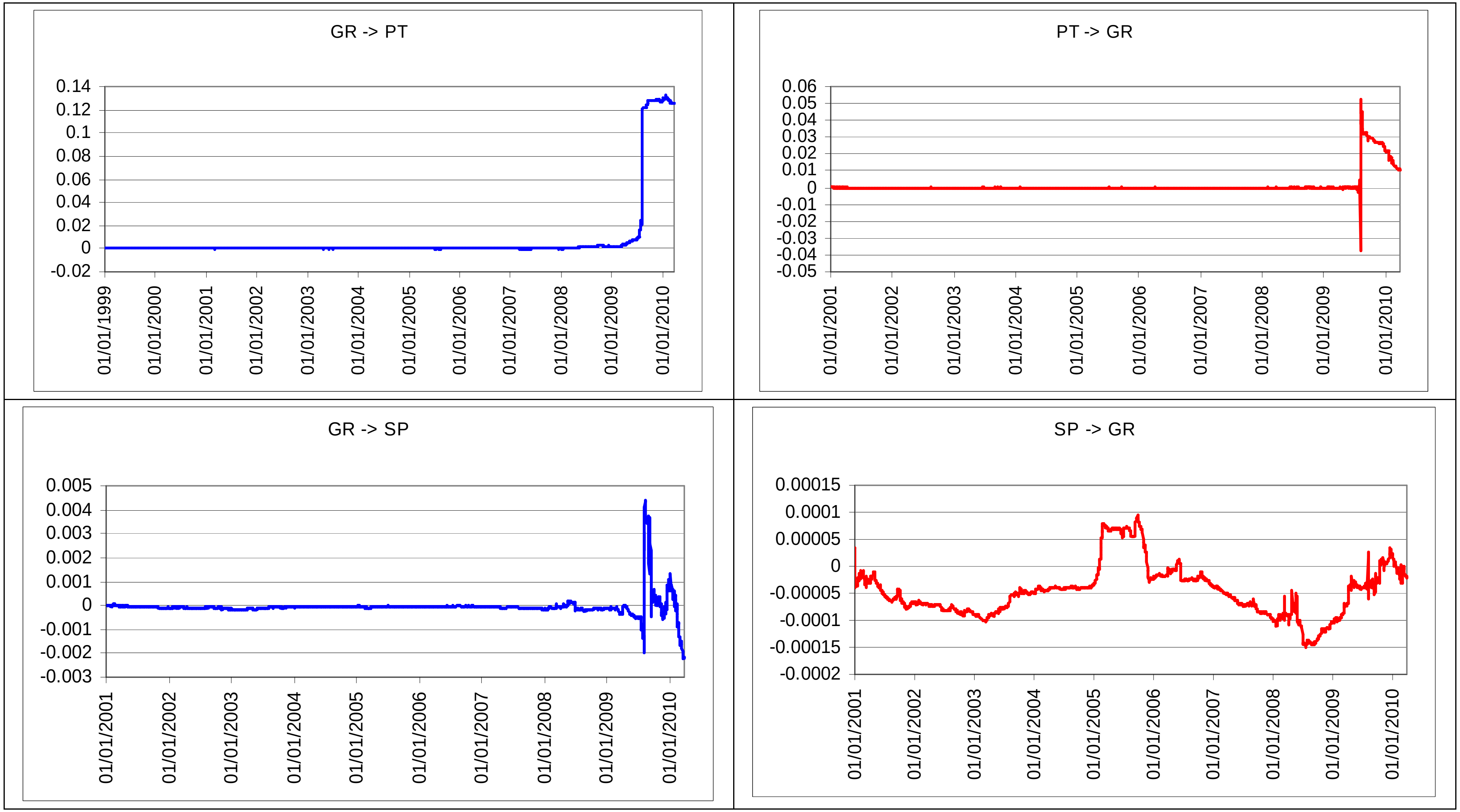


Figure 2: FPE sequence from rolling regressions

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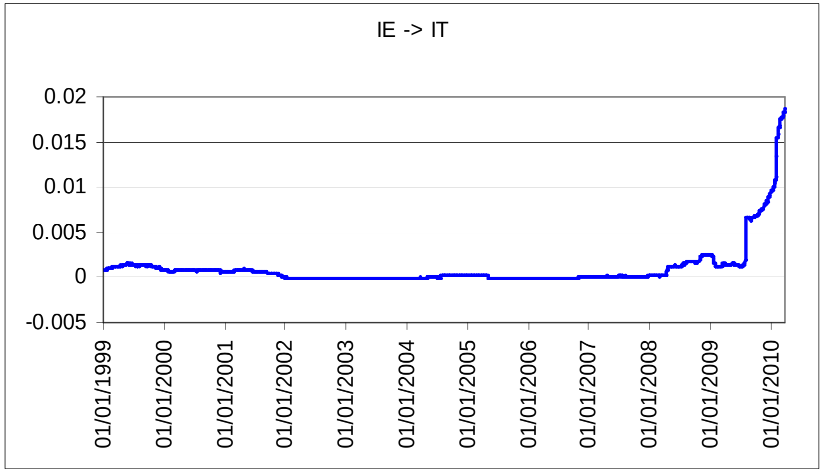
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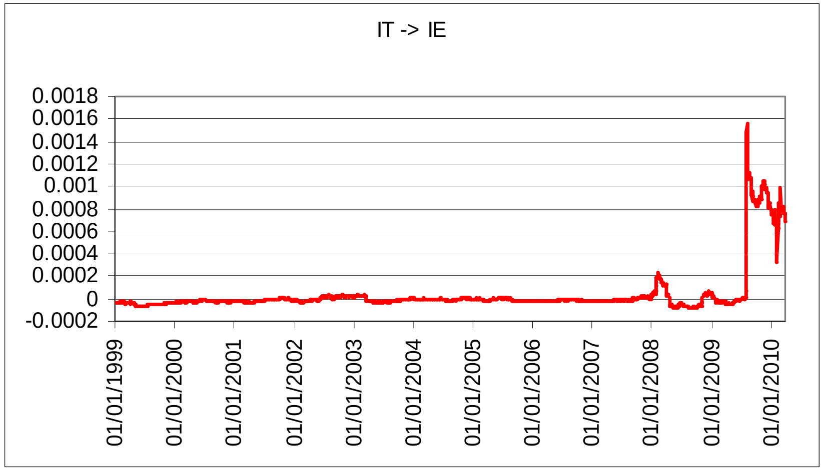
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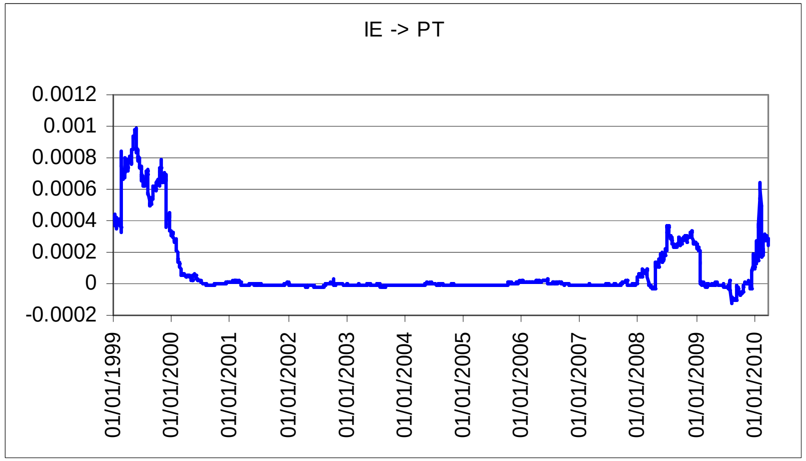
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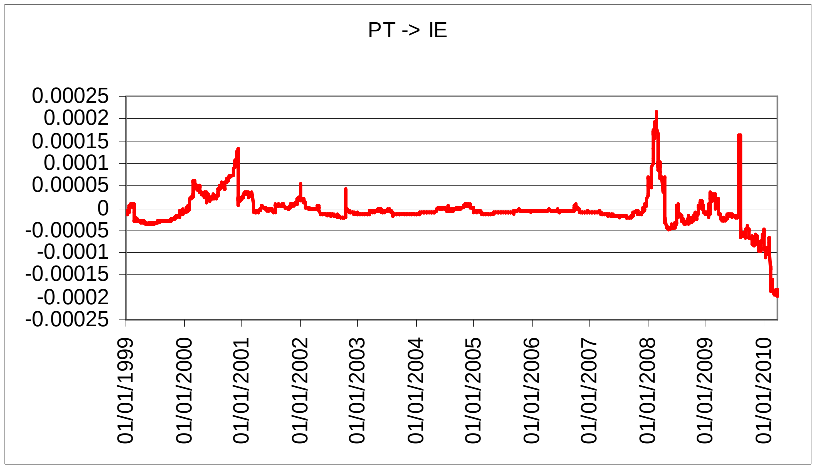
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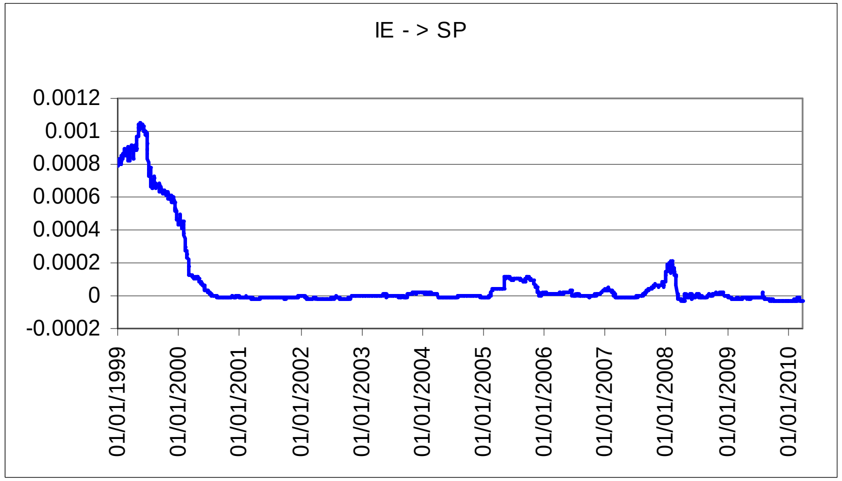
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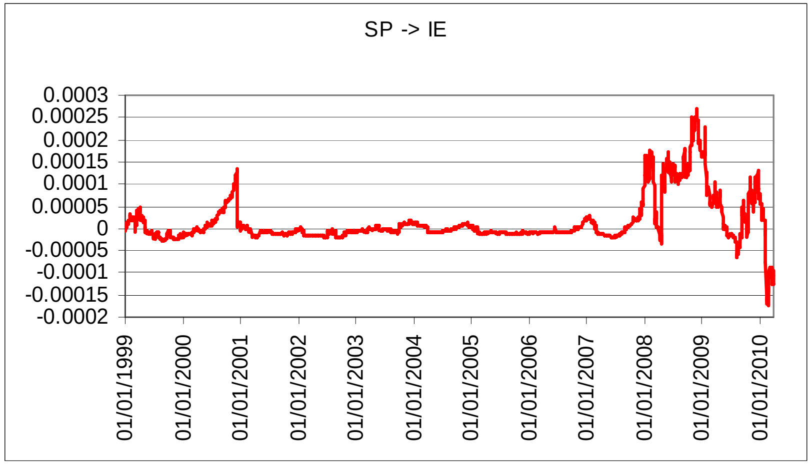
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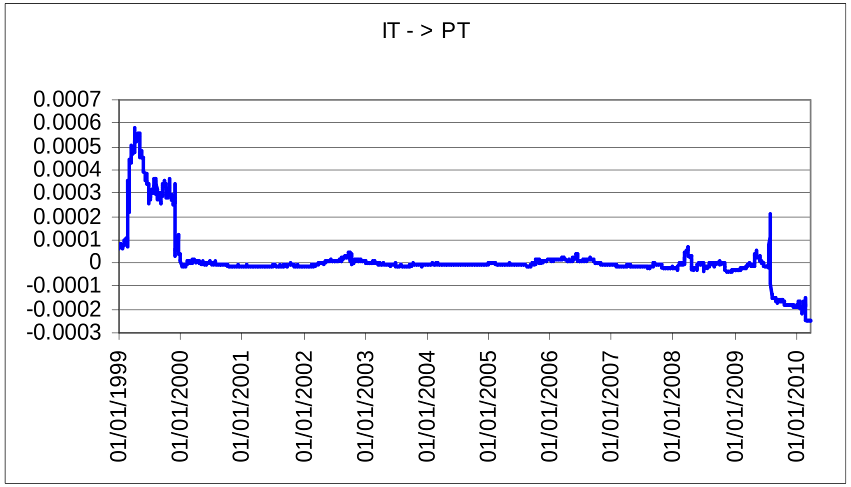
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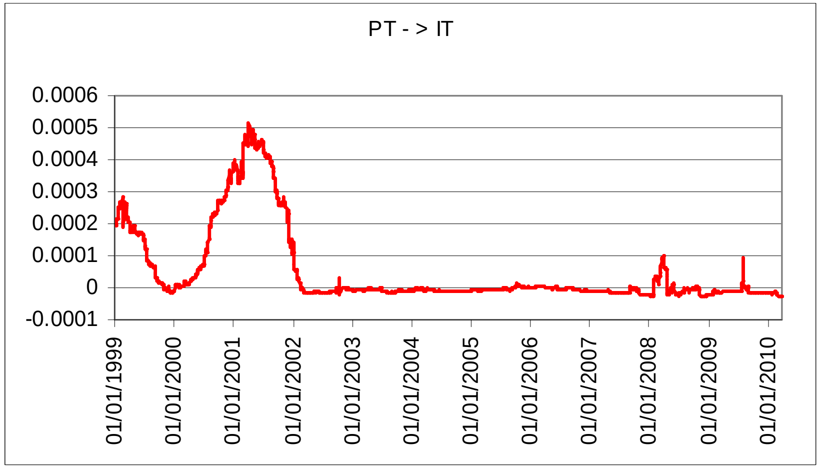
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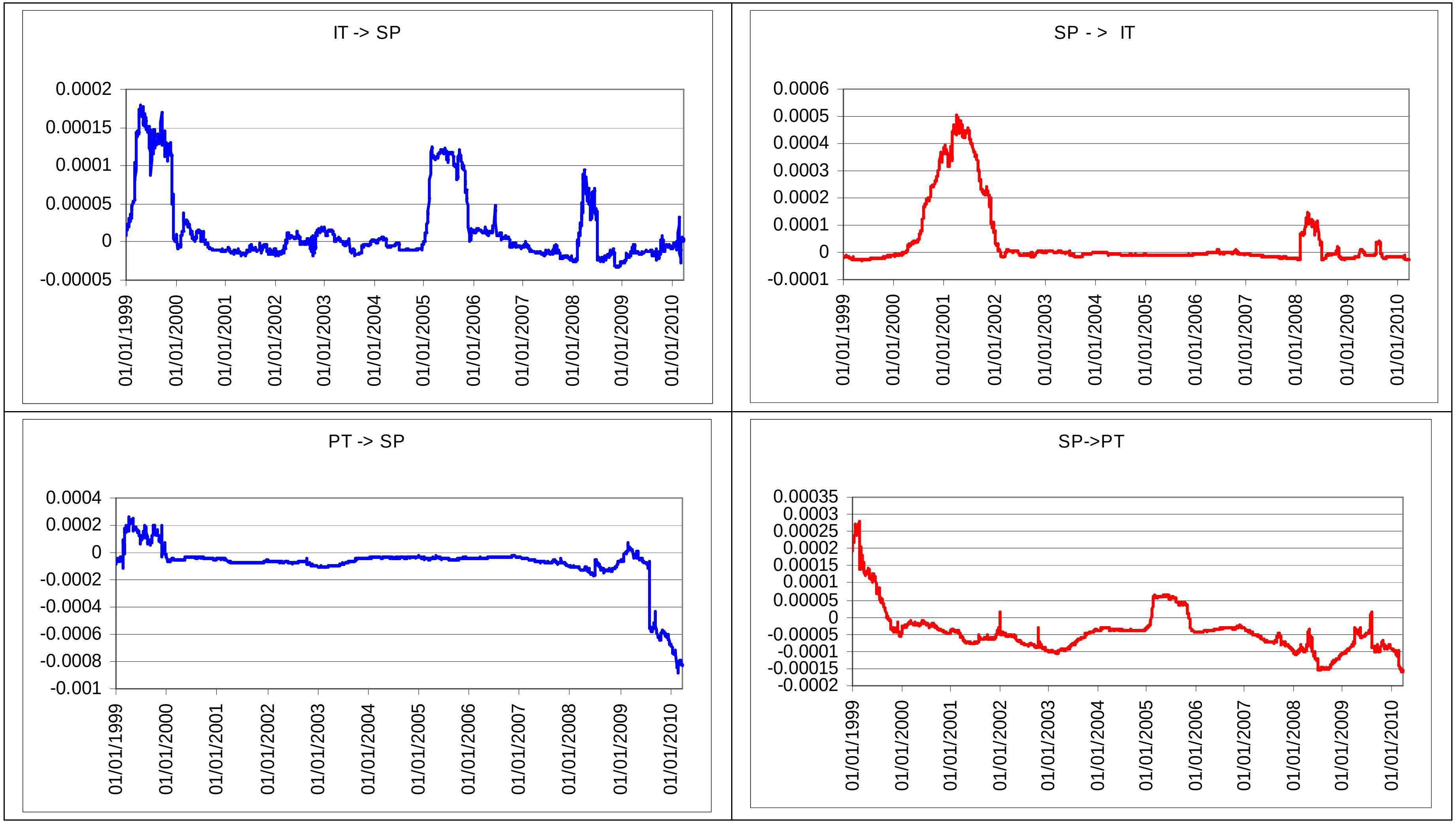
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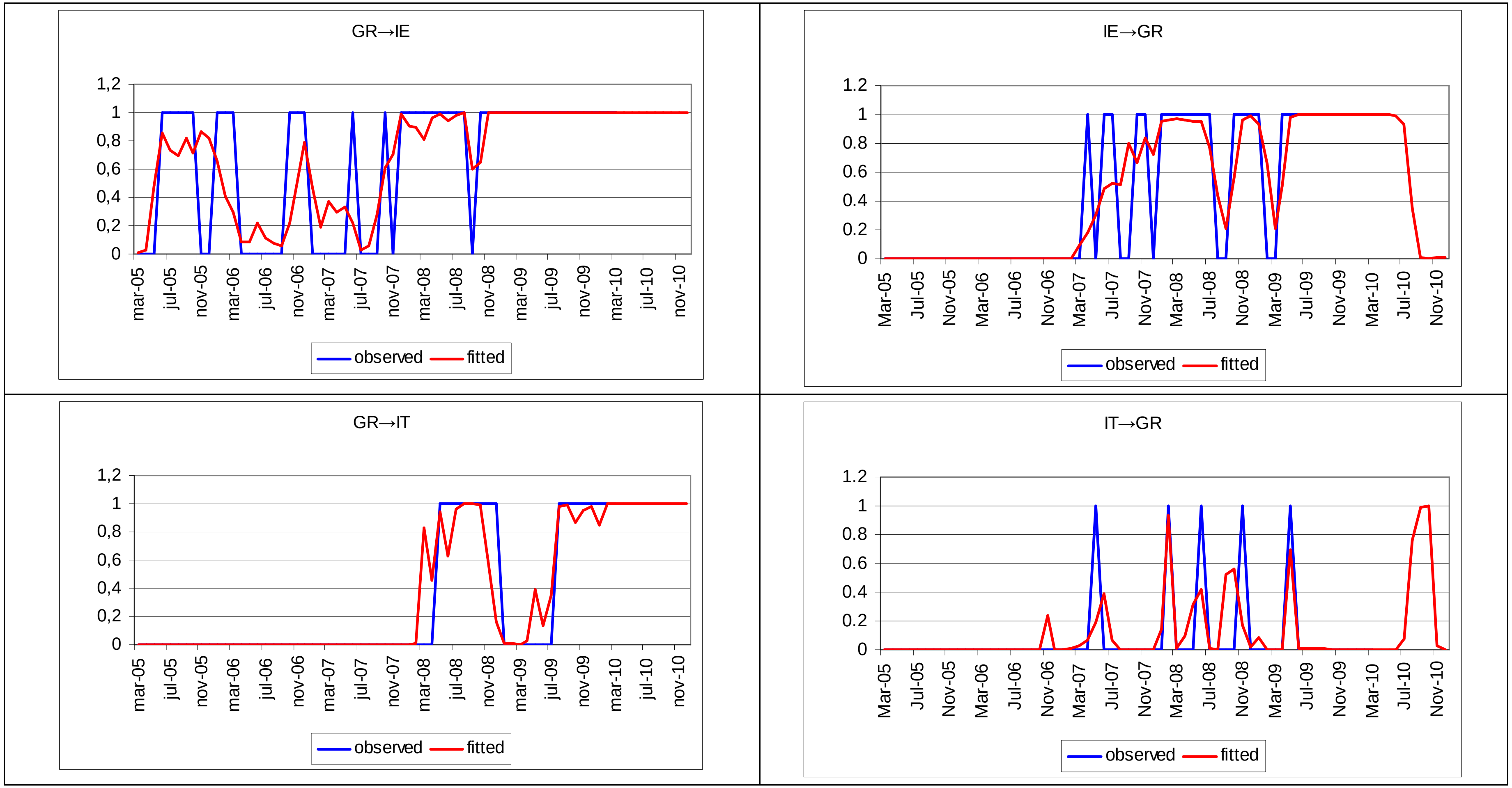
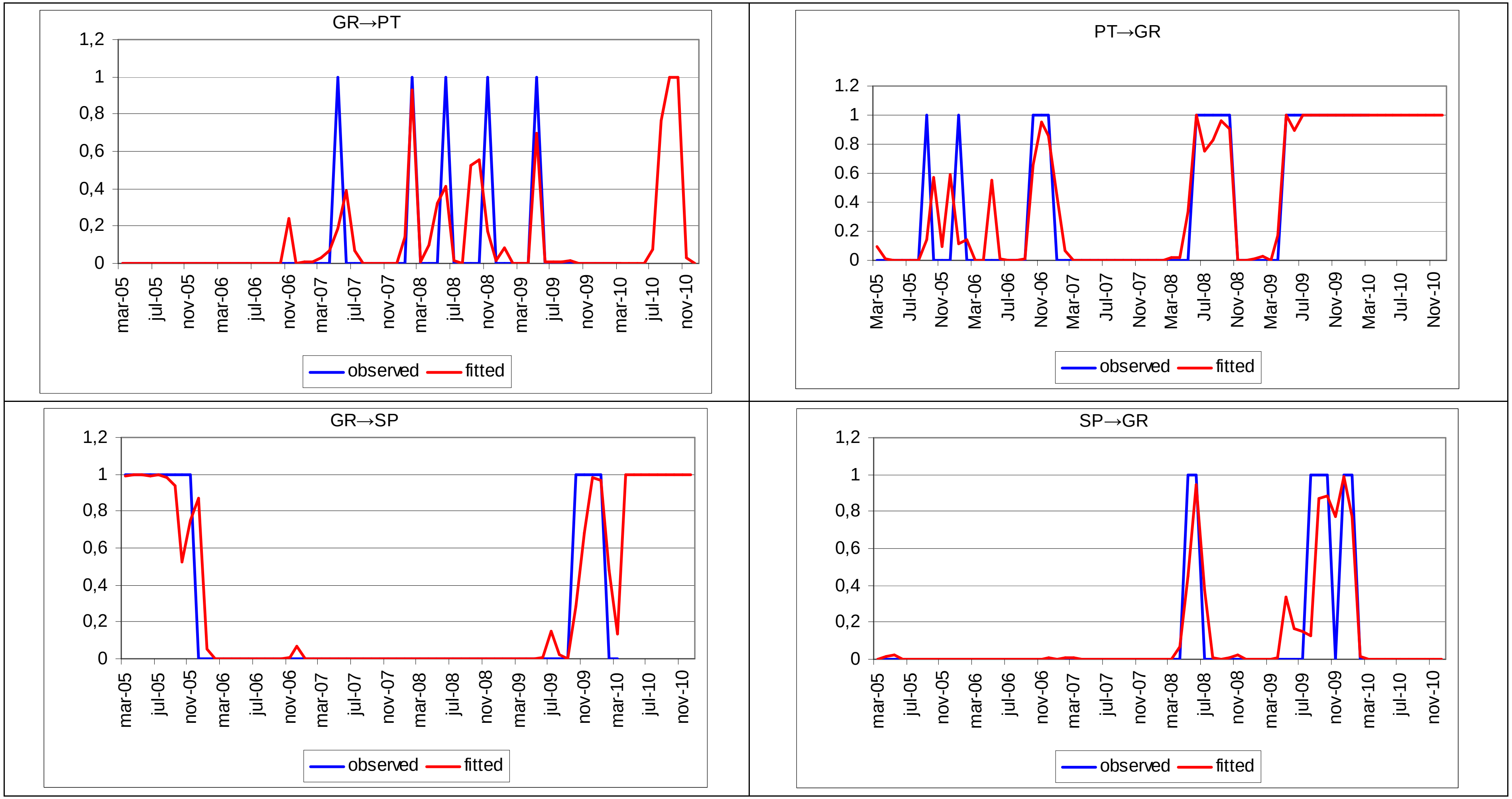
Figure 3: Probit results

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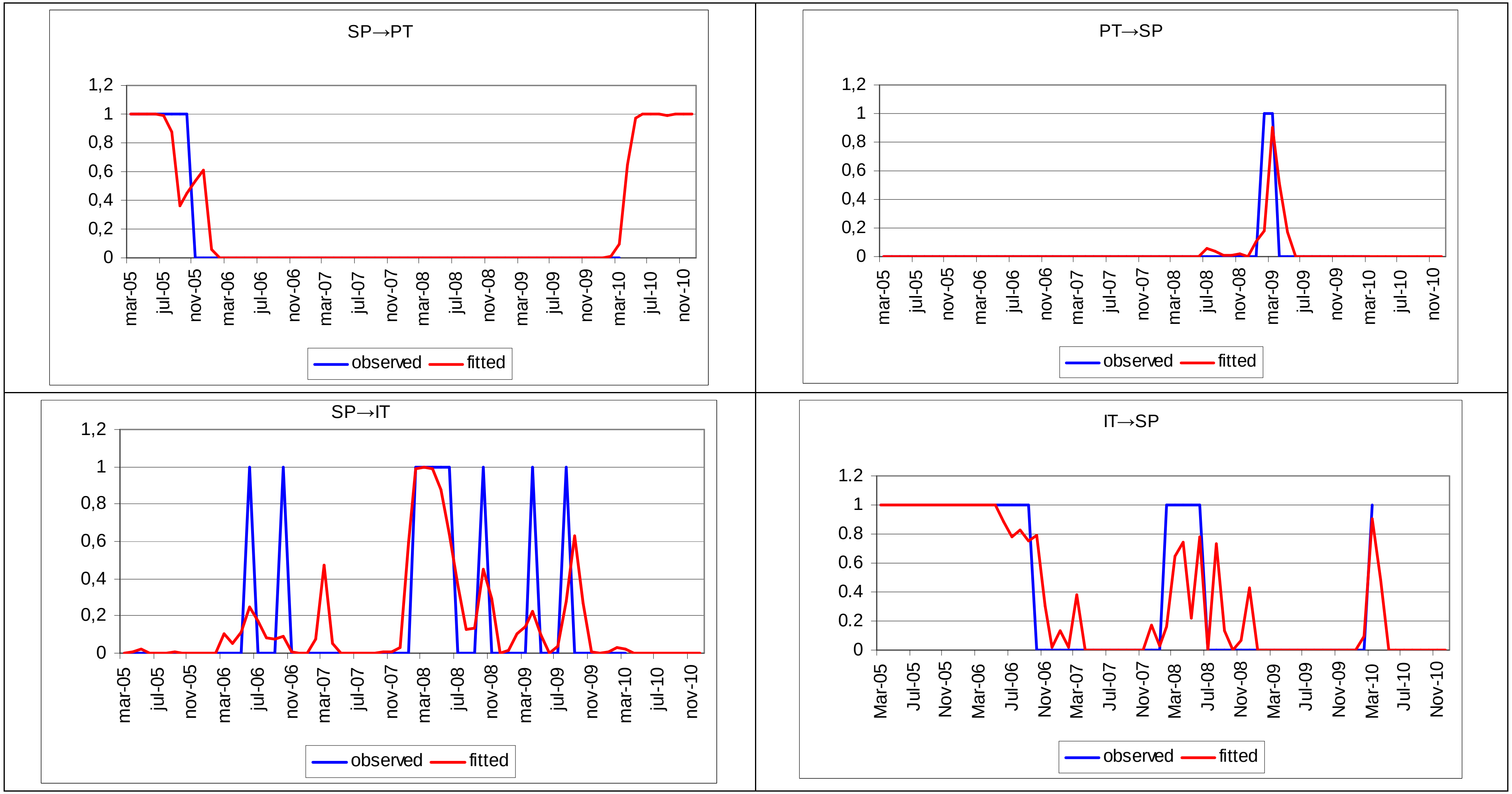
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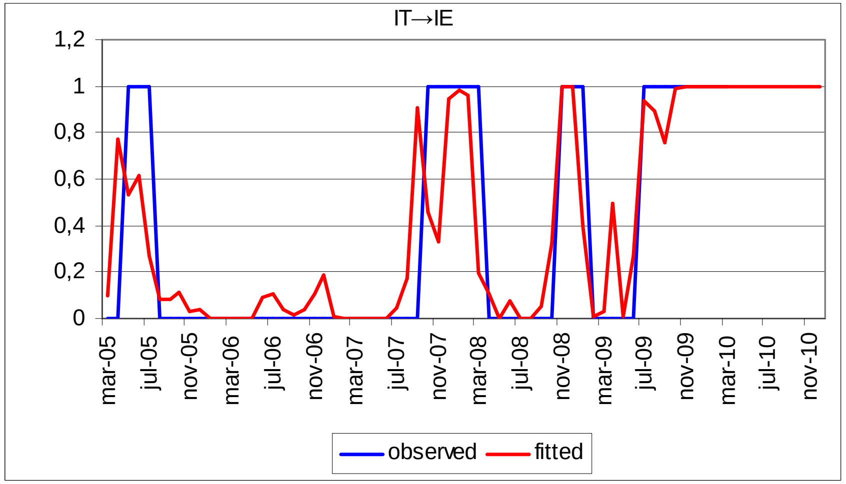
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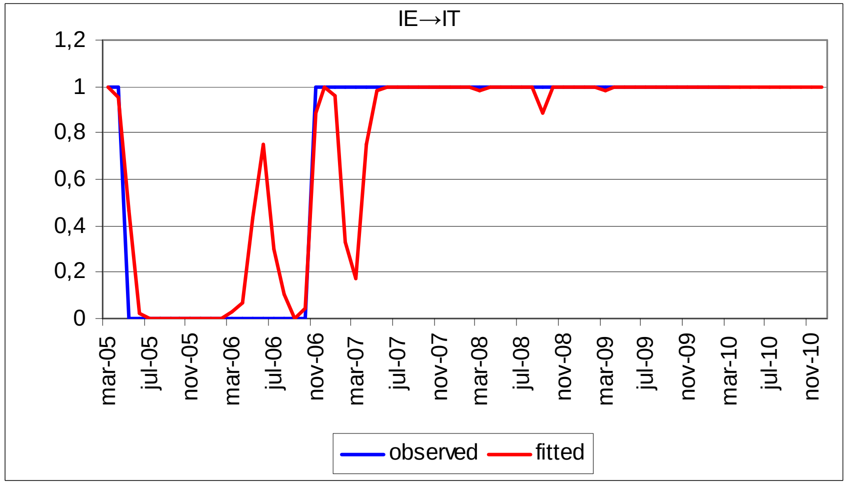
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observed
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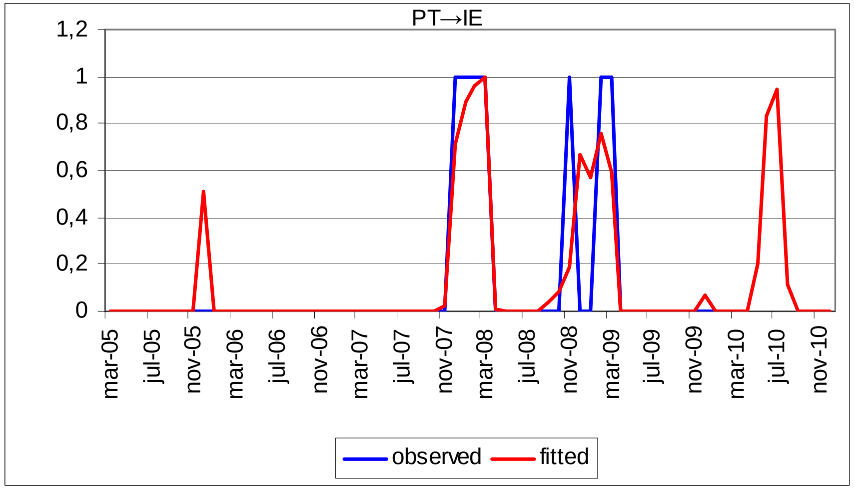
PT→IE
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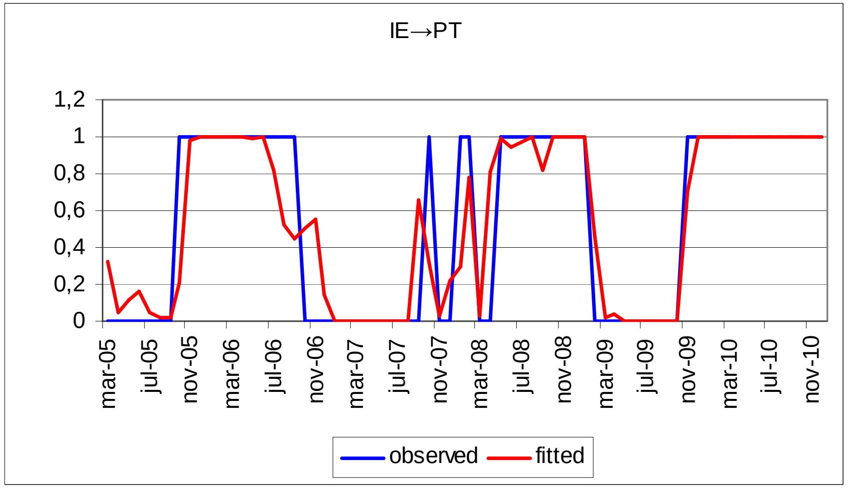
IE→PT
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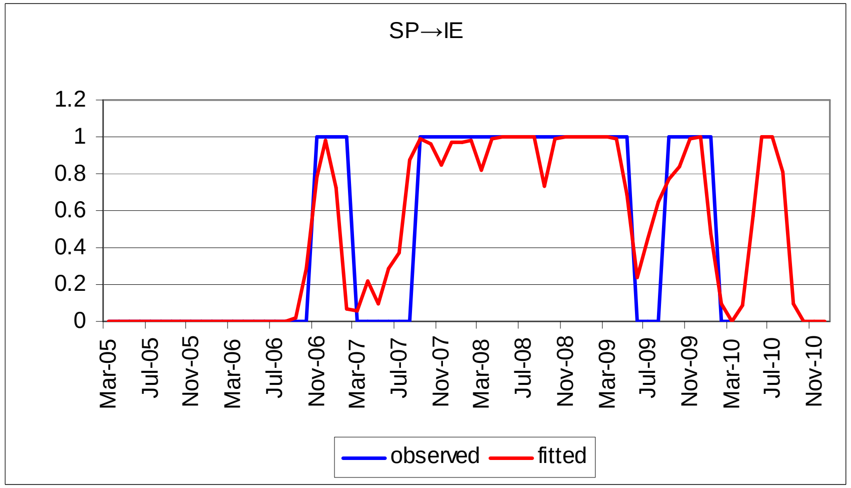

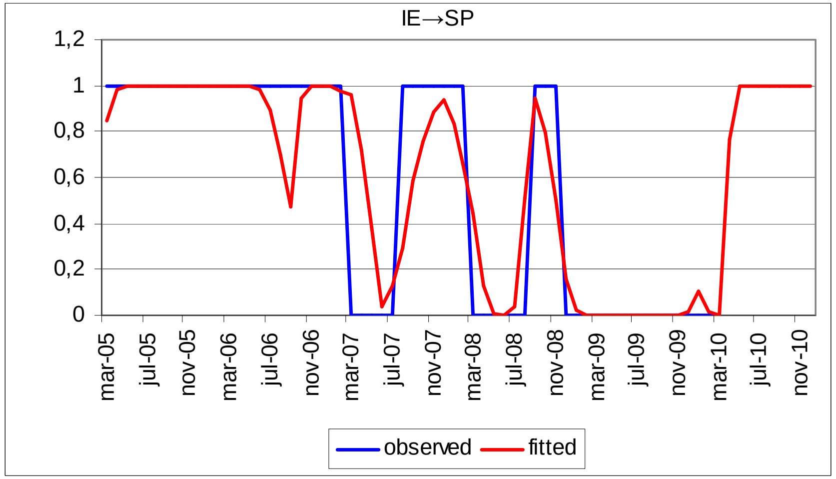

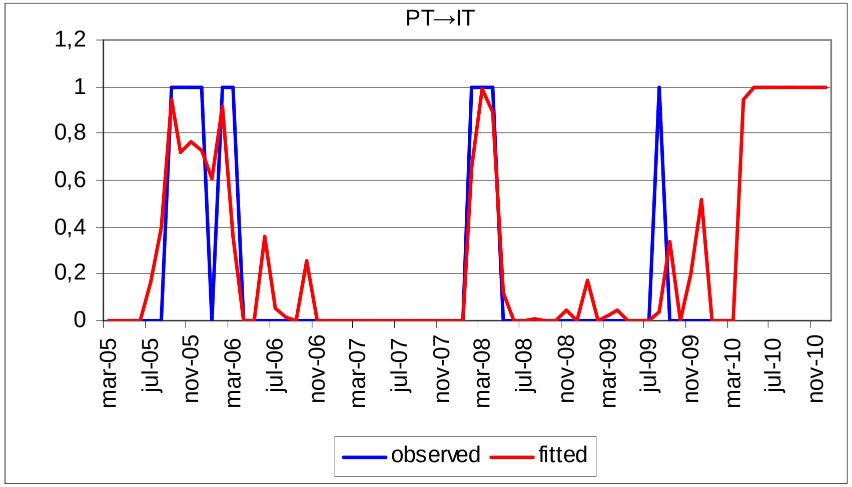

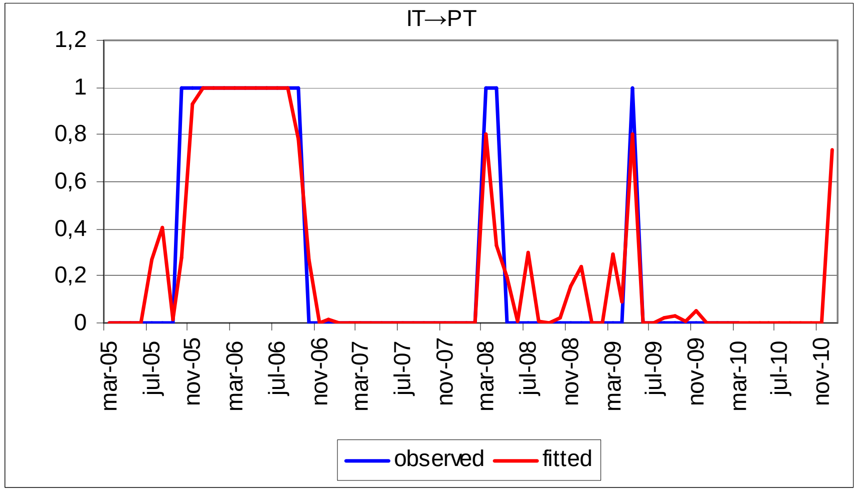

Note: GR, IE, IT, PT and SP stand for Greece, Ireland, Italy, Portugal and Spain respectively.

.

Table 1. Descriptive statistics

Panel A: Levels

	GR	IE	IT	PT	SP
Mean	4.995	4.543	4.491	4.541	4.379
Median	4.544	4.459	4.374	4.405	4.232
Maximum	12.440	9.012	5.879	7.104	5.870
Minimum	3.206	3.038	3.215	2.997	3.025
Std. Dev.	1.637	0.828	0.615	0.722	0.650
Skewness	2.714	1.236	0.343	0.423	0.376
Kurtosis	10.589	7.304	2.268	2.793	2.230
Jarque-Bera	9468.5	3213.9	131.5	99.0	151.2
Observations	2610	3131	3131	3131	3131
Panel B: First differences					
	DGR	**DIE**	**DIT**	**DPT**	**DSP**
Mean	0.003	0.002	0.000	0.001	0.000
Median	0.000	0.000	0.000	0.000	0.000
Maximum	1.304	0.682	0.213	0.546	0.253
Minimum	-4.323	-1.028	-0.319	-1.470	-0.441
Std. Dev.	0.117	0.058	0.041	0.062	0.044
Skewness	-17.879	-1.162	0.181	-4.230	-0.077
Kurtosis	720.496	48.784	5.562	113.490	7.960
Jarque-Bera	56102048.0	274076.8	873.0	1601451.0	3211.0
Observations	2609	3130	3130	3130	3130

Note: GR, IE, IT, PT and SP stand for Greece, Ireland, Italy, Portugal and Spain respectively.

Table 2. Augmented Dickey- Fuller tests for unit roots.

Panel A: I (2) versus I (1) (Variables in first differences)			
	τ_τ	τ_μ	τ
GR	-17.8072*	-17.6380*	-17.5929*
IE	-47.7382*	-47.7020*	-47.6802*
IT	-52.3394*	-52.3468*	-52.3535*
PT	-31.6051*	-31.5955*	-31.5838*
SP	-51.8722*	-51.8773*	-51.8802*
Panel B: I (1) versus I (0) (Variables in levels)			
	τ_τ	τ_μ	τ
GR	0.2766	1.2043	1.5440
IE	0.3425	0.3400	1.3145
IT	-2.6923	-2.0867	0.0225
PT	-1.0206	-1.2202	0.6855
SP	-1.8358	-1.7678	0.2859

Notes:
The ADF statistic is a test for the null hypothesis of a unit root.
τ_τ, τ_μ and τ denote the ADF statistics with drift and trend, with drift, and without drift, respectively.
* denotes significance at the 1% level. Critical values based on MacKinnon (1996)
GR, IE, IT, PT and SP stand for Greece, Ireland, Italy, Portugal and Spain respectively.

Table 3. KPSS tests for stationarity

Panel A: I (2) versus I (1) (Variables in first differences)			
		τ_τ	τ_μ
GR		0.1052	0.2574
IE		0.0877	0.3287
IT		0.1083	0.1072
PT		0.1103	0.1868
SP		0.0975	0.1551
Panel B: I (1) versus I (0) Variables in leves)			
		τ_τ	τ_μ
GR		0.9832*	1.8948*
IE		1.1606*	1.1528*
IT		0.6825*	2.9237*
PT		0.9373*	1.6140*
SP		0.8374*	3.0079*

Notes:
The KPSS statistic is a test for the null hypothesis of stationarity.
τ_τ and τ_μ denote the KPSS statistics with drift and trend, and with drift, respectively.
* denotes significance at the 1% level. Asymptotic critical values based on Kwiatkowski *et al.* (1992. Table 1)
GR, IE, IT, PT and SP stand for Greece, Ireland, Italy, Portugal and Spain respectively.

Table 4. Cointegration tests

	Hypothesized numbers of cointegrating relations	Trace statistic[a]	p-value[b]
GR. IE	None At most one	20.3839** 1.0135	0.0481 0.9498
GR. IT	None At most one	16.5832 3.0084	0.1488 0.5791
GR. PT	None At most one	21.0916** 2.8721	0.0384 0.6049
GR. SP	None At most one	14.7411 2.6170	0.2416 0.6544
IE. IT	None At most one	12.6781 1.2744	0.3901 0.9118
IE. PT	None At most one	10.2764 1.7622	0.6127 0.8244
IE. SP	None At most one	9.67O6 1.0393	0.6721 0.9464
IT. PT	None At most one	9.2582 1.8854	0.7119 0.8004
IT. SP	None At most one	13.5751 2.7382	0.3197 0.6307
PT. SP	None At most one	15.5181 2.9255	0.1981 0.5947

Notes:
* and ** denote rejection of the hypothesis at the 1% and 5% level, respectively.
MacKinnon *et al.* (1999)'s p-values.
GR, IE, IT, PT and SP stand for Greece, Ireland, Italy, Portugal and Spain respectively.

Table 5. FPE statistics for the whole sample

	FPE(m.0)x10^{-3}	FPE(m.n) x10^{-3}	Causality
GR → IE	3.4311 (1.0)	3.3972 (1.1)	Yes
IE → GR	13.1864 (4.0)	12.8586 (4.4)	Yes
GR → IT	1.6707 (1.0)	1.6695 (1.1)	Yes
IT → GR	13.1864 (4.0)	13.0770 (4.1)	Yes
GR → PT	3.5423 (4.0)	3.5096 (4.1)	Yes
PT → GR	13.1864 (4.0)	12.6075 (4.4)	Yes
GR → SP	1.9055 (4.0)	1.9063 (4.1)	No
SP → GR	13.1864 (4.0)	13.1102 (4.4)	Yes
IE → IT	1.6910 (1.0)	1.6586 (1.1)	Yes
IT → IE	3.2584 (1.0)	3.2596 (1.1)	Yes
IE → PT	3.8007 (4.0)	3.6855 (4.1)	Yes
PT → IE	3.2584 (1.0)	3.2602 (1.1)	No
IE → SP	1.9248 (4.0)	1.8941 (4.1)	Yes
SP → IE	3.2584 (1.0)	1.9248 (1.4)	Yes
IT → PT	3.8007 (4.0)	3.7989 (4.1)	Yes
PT → IT	1.6910 (1.0)	1.6812 (1.1)	Yes
IT → SP	1.9248 (4.0)	1.9214 (4.1)	Yes
SP → IT	1.6910 (1.0)	1.6878 (1.1)	Yes
PT → SP	1.9248 (4.0)	1.9183 (4.1)	Yes
SP → PT	3.8007 (4.0)	3.7832 (4.11)	Yes

Notes:
The figures in brackets are the optimum order of lags in each pair of countries
GR, IE, IT, PT and SP stand for Greece, Ireland, Italy, Portugal and Spain respectively.

Table 6. Debt-to-GDP by sector.

GREECE	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average 2002-06 (I)	Average 2007-10 (II)	% (II)/(I)
Banks	24.6	26.0	25.5	28.4	33.7	48.4	63.2	68.5	97.6	**27.6**	**69.4**	**151%**
Households	19.5	22.6	27.0	32.6	37.0	40.4	40.8	41.5	59.9	**35.7**	**45.6**	**28%**
Non-financial corporations	32.6	33.2	34.0	37.5	39.0	43.1	50.9	48.0	53.0	**41.3**	**48.8**	**18%**
General Government	101.7	97.4	98.9	109.0	106.4	105.4	110.7	127.1	142.8	**111.0**	**121.5**	**9%**
IRELAND	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average 2002-06 (I)**	**Average 2007-10 (II)**	**% (II)/(I)**
Banks	287.1	329.0	399.3	491.9	579.6	609.7	726.1	753.6	729.1	**417.4**	**704.6**	**69%**
Households	43.9	48.5	60.9	70.9	77.8	81.2	84.8	92.3	89.5	**72.2**	**86.9**	**20%**
Non-financial corporations	40.2	44.0	55.4	63.6	79.9	91.3	105.9	107.2	72.0	**73.3**	**94.1**	**28%**
General Government	30.7	31.0	29.5	27.4	24.8	25.0	44.4	65.6	96.2	**41.6**	**57.8**	**39%**
ITALY	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average 2002-06 (I)**	**Average 2007-10 (II)**	**% (II)/(I)**
Banks	65.5	69.4	71.9	77.1	85.6	94.1	104.1	105.9	104.3	**73.9**	**102.1**	**38%**
Households	21.5	23.0	25.1	27.0	28.5	29.8	30.3	32.7	38.1	**28.4**	**32.7**	**15%**
Non-financial corporations	44.4	46.4	47.4	48.0	51.7	56.8	60.9	61.7	62.3	**53.3**	**60.4**	**13%**
General Government	105.7	104.4	103.9	105.9	106.6	103.6	106.3	116.1	119.0	**107.9**	**111.3**	**3%**
PORTUGAL	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average 2002-06 (I)**	**Average 2007-10 (II)**	**% (II)/(I)**
Banks	106.3	113.3	101.6	103.8	115.3	126.4	136.6	156.3	182.5	**108.1**	**150.4**	**39%**
Households	59.3	58.6	60.4	64.5	70.7	74.5	78.3	81.7	82.3	**70.0**	**79.2**	**13%**
Non-financial corporations	68.2	67.9	67.2	70.8	72.7	78.7	90.8	93.0	90.6	**77.8**	**88.3**	**14%**
General Government	53.8	55.9	57.6	62.8	69.5	68.3	71.6	83.0	93.0	**68.4**	**79.0**	**15%**
SPAIN	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average 2002-06 (I)**	**Average 2007-10 (II)**	**% (II)/(I)**
Banks	72.4	78.5	84.7	107.3	116.9	133.7	150.1	161.4	159.2	**92.0**	**151.1**	**64%**
Households	47.5	51.1	55.8	66.4	74.2	78.3	81.9	83.5	82.1	**69.0**	**81.4**	**18%**
Non-financial corporations	47.1	49.6	53.8	63.0	76.3	85.5	91.2	90.4	87.0	**71.6**	**88.5**	**24%**
General Government	52.5	48.7	46.2	43.0	39.6	36.1	39.8	53.3	60.1	**46.6**	**47.3**	**2%**

Note: Debt-to-GDP at the end of each year.
Source: Eurostat, Monetary Financial Institutions (MFIs) balance sheets obtained from the European Central Bank and authors' estimates.

Table 7. Foreign banks' claims on individual countries-to-GDP by sector.

Foreign banks' claims on public sector debt/GDP							
	2005	2006	2007	2008	2009	2010	Average
GREECE	30.79	33.64	36.07	30.56	29.93	17.64	29.77
IRELAND	4.78	6.19	7.56	8.37	15.19	11.69	8.96
ITALY	20.59	21.55	23.24	21.45	24.05	13.07	20.66
PORTUGAL	19.47	22.03	20.61	20.60	24.00	12.68	19.90
SPAIN	8.46	8.86	8.16	7.50	9.21	6.73	8.15
Foreign banks' claims on banks debt/GDP							
	2005	2006	2007	2008	2009	2010	Average
GREECE	6.23	7.02	10.04	12.17	10.33	3.55	8.23
IRELAND	103.93	120.21	140.62	100.51	92.71	51.09	101.51
ITALY	10.85	12.87	14.97	11.03	9.46	7.38	11.09
PORTUGAL	15.77	19.14	23.58	19.71	21.08	15.88	19.19
SPAIN	16.72	20.78	26.61	23.51	23.03	14.91	20.93
Foreign banks' claims on non-financial private sector debt/GDP							
	2005	2006	2007	2008	2009	2010	Average
GREECE	16.73	27.42	35.73	36.01	26.07	26.22	28.03
IRELAND	133.91	177.50	251.16	269.12	252.07	213.98	216.29
ITALY	11.60	20.67	28.28	23.07	24.97	22.83	21.90
PORTUGAL	32.12	38.35	46.84	46.22	49.83	45.57	43.15
SPAIN	17.38	25.38	33.61	29.83	30.52	25.09	26.97

Note: Reliance on foreign bank financing is measured by the consolidated claims on an immediate borrower basis of Bank for International Settlements (BIS) reporting banks on each sector (public, banks and non-financial corporations as a proportion of GDP). Data correspond to the end of each year.
Source: This table has been constructed from data collected from Table 9C of BIS Quarterly Review: June 2011 and the OECD.

Table 8. Claims by nationality of reporting banks as a proportion of total foreign claims.

GREECE	2005	2006	2007	2008	2009	2010	Average
Austrian banks	3.3	2.8	2.4	2.1	2.2	2.3	2.5
Belgian banks	8.7	5.6	5.7	3.8	2.0	1.3	4.5
Finnish banks	0.0	0.0	0.0	0.0	0.0	0.0	0.0
French banks	9.4	19.1	24.4	28.4	36.7	39.6	26.2
German banks	22.0	18.1	15.9	14.5	20.9	23.7	19.2
Irish banks	0.0	5.6	3.6	3.2	4.0	0.6	2.8
Italian banks	2.2	0.0	4.3	3.6	3.2	2.9	2.7
Dutch banks	11.3	8.8	7.9	4.9	5.7	3.5	7.0
Portuguese banks	1.9	2.3	2.5	2.4	4.6	7.2	3.5
Spanish banks	0.6	0.3	0.4	0.4	0.6	0.7	0.5
British banks	5.4	4.6	5.5	4.8	7.1	9.8	6.2
US banks	5.0	4.1	3.4	2.6	7.7	5.1	4.6
Others	30.3	28.7	24.0	29.3	5.4	3.3	20.2
IRELAND	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average**
Austrian banks	1.22	1.39	1.16	0.76	1.27	0.64	1.1
Belgian banks	8.82	10.52	8.42	6.75	5.68	5.62	7.6
Finnish banks	0.00	0.00	0.00	0.00	0.00	0.16	0.0
French banks	7.30	9.06	12.02	10.10	8.47	6.55	8.9
German banks	25.78	23.95	25.90	29.97	29.88	26.13	26.9
Greek banks	0.22	0.12	0.07	0.05	0.10	0.11	0.1
Italian banks	3.71	2.96	3.43	3.62	2.83	2.99	3.3
Dutch banks	9.92	7.49	5.69	5.25	4.58	3.70	6.1
Portuguese banks	0.52	0.75	0.40	0.56	0.76	1.14	0.7
Spanish banks	3.11	3.81	3.04	2.20	2.38	2.22	2.8
British banks	26.49	26.91	26.21	28.22	27.12	29.91	27.5
US banks	3.15	3.97	4.51	4.89	9.28	11.27	6.2
Others	9.77	9.07	9.15	7.63	7.67	9.57	8.8
PORTUGAL	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average**
Austrian banks	1.39	1.31	1.09	1.11	1.15	0.81	1.1
Belgian banks	5.14	6.65	4.77	5.28	2.33	1.75	4.3
Finnish banks	0.00	0.00	0.00	0.00	0.00	0.19	0.0
French banks	10.28	10.55	13.79	13.11	17.83	13.33	13.1
German banks	20.64	19.27	20.05	19.50	18.79	18.03	19.4
Greek banks	0.02	0.01	0.02	0.02	0.05	0.04	0.0
Irish banks	0.00	4.30	3.62	2.78	2.16	1.35	2.4
Italian banks	3.18	3.83	3.39	2.72	2.66	2.01	3.0
Dutch banks	7.45	6.66	7.39	6.07	5.61	3.24	6.1
Spanish banks	35.12	31.99	32.23	33.93	33.71	41.89	34.8
British banks	11.17	8.68	8.55	9.62	10.20	12.05	10.0
US banks	1.64	2.26	1.51	0.81	1.85	2.61	1.8
Others	3.98	4.50	3.60	5.05	3.66	2.70	3.9
SPAIN	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average**
Austrian banks	0.86	0.87	0.82	0.87	0.96	0.95	0.9
Belgian banks	4.22	4.52	4.44	4.82	2.46	3.06	3.9
Finnish banks	0.00	0.00	0.00	0.00	0.00	0.22	0.0
French banks	18.25	14.94	18.92	19.35	22.97	20.01	19.1
German banks	26.51	30.07	29.23	27.83	25.89	25.88	27.6
Greek banks	0.06	0.01	0.01	0.03	0.04	0.05	0.0
Irish banks	0.00	3.86	3.84	3.70	3.45	2.13	2.8
Italian banks	2.49	2.34	2.70	3.12	3.39	4.22	3.0
Dutch banks	16.87	13.95	13.36	13.69	13.02	10.94	13.6
Portugal banks	2.61	2.84	2.77	3.14	3.14	3.80	3.0
British banks	15.23	13.84	12.55	13.66	11.98	15.25	13.8
US banks	4.55	4.72	4.12	3.67	6.31	6.72	5.0
Others	8.35	8.02	7.25	6.12	6.37	6.78	7.1
ITALY	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Average**
Austrian banks	2.64	2.19	2.04	1.61	2.23	2.58	2.2
Belgian banks	10.85	8.09	4.38	4.74	2.83	2.99	5.6
Finnish banks	0.00	0.00	0.00	0.00	0.00	0.08	0.0
French banks	18.94	27.45	37.66	42.79	44.44	45.53	36.1
German banks	25.26	20.10	19.41	18.91	16.60	18.82	19.9
Greek banks	0.15	0.07	0.02	0.03	0.06	0.07	0.1
Irish banks	0.00	5.20	3.94	4.25	3.99	1.53	3.2
Dutch banks	10.84	13.82	11.65	6.11	6.04	5.26	9.0
Portuguese banks	0.76	0.75	0.41	0.32	0.47	0.35	0.5
Spanish banks	4.44	2.99	2.82	4.44	4.13	3.62	3.7
British banks	9.22	7.02	7.09	6.83	6.71	7.70	7.4
US banks	5.78	3.25	2.79	2.33	4.66	4.26	3.8
Others	11.12	9.08	7.78	7.65	7.84	7.21	8.4

Note: This table displays the consolidated claims on an immediate borrower basis of Bank for International Settlements (BIS) by nationality of reporting banks as a proportion of total foreign claims on each country. Data correspond to the end of each year.

Source: This table has been constructed from data collected from Table 9D of BIS Quarterly Review: June 2011.

Table 9: Basic Probit models

GREECE→IRELAND	Coefficient	z-Statistic	Marginal Effects
GRIEBAN	24.1353	2.7231	4.9887
GRGOVDEB	0.0832	2.7111	0.0407
UGR	0.1484	2.7271	0.0221
DEFIE	0.1458	2.7575	0.0299
IEBAN	0.0349	2.6138	0.0169
IEPRI	0.0202	2.6609	0.0067
GRBANDEB	0.2191	2.6501	0.0471
ILLIQUIDITY	-0.0156	-2.9549	-0.0032
RISK	0.1295	2.9691	0.0273
McFadden R-squared	0.6557		

IRELAND→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-2.8209	-2.0814	
IEGRBAN	92.3251	2.8192	9.7876
IEPUB	1.1926	2.9471	0.1264
DEFIE	0.0995	2.6126	0.0106
ILLIQUIDITY	-0.0006	-3.0053	-0.0001
RISK	0.0085	2.8453	0.0009
McFadden R-squared	0.7208		

GREECE→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	7.1078	2.6859	
GRITBAN	0.2287	2.7850	0.0175
INFGR	3.1806	2.9841	0.2428
UGR	2.0831	3.3365	0.1590
RATGR	0.5570	2.8752	0.0425
GRGOVDEB	0.9750	2.9038	0.0744
ILLIQUIDITY	-0.0047	-2.9811	-0.0004
RISK	0.0083	2.8175	0.0006
McFadden R-squared	0.8925		

ITALY→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-205.1627	-2.8314	
ITGRBAN	4.5310	2.4544	0.2220
DEFIT	1.2724	2.8966	0.0624
ITBANDEB	0.1441	3.1095	0.0071
UIT	2.8524	3.0603	0.1398
RATGRE	7.5094	2.6833	0.3680
ITPUB	3.3801	2.8535	0.1656
ITHOUDEB	7.5080	2.8671	0.3679
ILLIQUIDITY	-0.0334	-2.9425	-0.0016
RISK	0.1247	2.9895	0.0061
McFadden R-squared	0.8185		

GREECE→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-1.4883	-2.1737	
GRPTBAN	11.5474	2.6035	0.5495
INFGR	1.5967	2.1735	0.0760
UGR	3.6620	2.7804	0.1743
GRGOVDEB	0.7714	3.4456	0.0367
RATPT	4.5239	3.6762	0.2153
GRNFIDEB	2.7992	3.6514	0.1332
GRPUB	1.3888	2.6463	0.0661
GRPRI	1.6746	3.2534	0.0797
ILLIQUIDITY	-0.0245	-3.0450	-0.0012
RISK	0.1684	2.9666	0.0080
McFadden R-squared	0.8977		

PORTUGAL→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-102.8202	-4.2521	
PTGRBAN	6.8272	3.3555	0.5908
INFPT	3.2865	3.9287	0.2845
UPT	9.6210	4.2726	0.8326
DEFPT	0.5114	2.8739	0.0443
PTNFIDEB	1.3531	2.7698	0.1171
PTPUB	0.7840	2.9360	0.0679
PTBANDEB	1.0601	2.8201	0.0917
ILLIQUIDITY	-0.0056	-2.9298	-0.0005
RISK	0.0563	2.7734	0.0049
McFadden R-squared	0.7728		

GREECE→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-3.1463	-2.7743	
GRSPBAN	7.1575	2.7096	0.3239
UGR	4.1697	2.7937	0.1887
GRGOVDEB	0.8516	2.8869	0.0385
DEFSP	0.3342	2.8237	0.0151
ILLIQUIDITY	-0.0283	-2.9415	-0.0013
RISK	0.1057	2.9530	0.0048
McFadden R-squared	0.8922		

SPAIN→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-166.5219	-3.8526	
SPGRBAN	58.1509	2.9586	2.8202
SPBANDEB	0.3220	2.6484	0.0156
SPNFIDEB	0.1352	2.7225	0.0066
RATGR	1.6073	2.7335	0.0779
RATSP	6.3187	2.7134	0.3064
CACSP	-0.9747	-2.6240	-0.0473
SPPUB	12.6118	3.2363	0.6116
ILLIQUIDITY	-0.0227	-2.6432	-0.0011
RISK	0.0671	2.7933	0.0033
McFadden R-squared	0.8241		

SPAIN→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-33.3138	-2.5337	
SPPTBAN	3.9060	2.6589	0.0798
SPNFIDEB	2.2087	3.2914	0.0451
UPT	4.8263	2.9294	0.0986
ILLIQUIDITY	-2.5741	-2.7826	-0.0526
RISK	16.0526	2.8207	0.3281
McFadden R-squared	0.8757		

PORTUGAL→SPAIN	Coefficient	z-Statistic	Marginal Effects
PTSPBAN	5.7793	2.6658	2.4918
DEFPT	0.5510	2.4995	0.2376
UPT	4.2108	2.7179	1.8156
INFPT	0.8085	2.4548	0.3486
RATPT	0.3399	2.5167	0.1466
USP	3.0030	3.0837	1.2948
SPGOVDEB	1.6101	2.7746	0.6942
ILLIQUIDITY	-0.0152	-3.0049	-0.0066
RISK	0.0976	2.8621	0.0421
McFadden R-squared	0.8813		

SPAIN→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	-9.0671	-2.0757	
SPITBAN	0.2236	2.8539	0.0229
DEFSP	0.0459	2.8283	0.0047
USP	0.1391	3.2145	0.0143
SPGOVDEB	0.1046	2.9165	0.0107
CACSP	-3.1720	-2.0677	-0.3248
UIT	0.4168	2.6827	0.0427
ITPUB	0.7403	2.9609	0.0235
RATIT	0.2292	2.7824	0.0335
ILLIQUIDITY	-0.0033	-2.7981	-0.0003
RISK	0.0343	2.9631	0.0035
McFadden R-squared	0.6827		

ITALY→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-22.5330	-2.4558	
ITSPBAN	3.5938	2.1105	0.3340
DEFIT	0.5818	2.9193	0.0541
ITBANDEB	0.2904	2.7865	0.0270
RATSP	17.4674	3.0117	1.6232
ITGOVDEB	0.3811	2.8774	0.0034
UIT	8.9632	2.8793	0.8329
ILLIQUIDITY	-0.0138	-2.9800	-0.0013
RISK	0.0954	3.0511	0.0089
McFadden R-squared	0.7647		

ITALY→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	81.7491	2.3772	
ITIEBAN	6.7565	3.2404	0.7457
DEFIT	0.2134	2.5847	0.0236
ITBANDEB	0.3547	2.4872	0.0391
UIT	1.7397	2.6153	0.1920
RATIE	2.3109	2.9536	0.2550
ITHOUDEB	1.0739	2.8998	0.1185
ITGOVDEB	0.7344	2.8797	0.0810
ILLIQUIDITY	-0.0462	-2.9328	-0.0051
RISK	0.1283	3.0925	0.0142
McFadden R-squared	0.7988		

IRELAND→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	-42.1838	-2.9923	
IEITBAN	0.1066	2.1082	0.0051
IEPUB	5.0826	2.9107	0.2413
DEFIE	0.7541	2.3964	0.0358
INFIE	2.6574	2.3384	0.1262
ILLIQUIDITY	-0.0097	-2.3395	-0.0005
RISK	0.3243	2.3174	0.0254
McFadden R-squared	0.8542		

PORTUGAL→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	-1.3615	-3.0357	
PTIEBAN	30.0192	3.6928	1.7235
DEFPT	1.3372	3.1335	0.7677
UPT	0.1562	3.5813	0.0090
INFPT	0.6976	2.5632	0.0401
RATPT	0.6857	2.9878	0.0394
UIE	0.1968	2.9959	0.0113
IEGOVDEB	0.0406	3.1005	0.0023
ILLIQUIDITY	-0.0067	-2.9984	-0.0004
RISK	0.0543	2.9977	0.0031
McFadden R-squared	0.8461		

IRELAND→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-77.1064	-3.3266	
IEPTBAN	0.6762	2.9035	0.0668
IEPUB	0.5208	2.3844	0.0514
DEFIE	0.5525	3.1395	0.0546
UIE	6.7134	2.8486	0.6633
IEBAN	0.0469	2.3453	0.0046
IEGOVDEB	1.5840	3.4880	0.1565
UPT	1.8076	2.9117	0.1786
CACPT	-4.4950	-3.5654	-0.4441
ILLIQUIDITY	-0.0641	-2.9021	-0.0063
RISK	0.2104	2.9585	0.0208
McFadden R-squared	0.8985		

SPAIN→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	-56.1863	-2.6820	
SPIEBAN	10.8287	2.8759	1.1461
DEFSP	0.0785	2.5219	0.0082
USP	4.0046	2.6632	0.4244
SPBAN	0.4589	2.5612	0.0484
SPGOVDEB	0.7956	3.1273	0.0842
CACSP	-1.1953	-2.3552	-0.1254
UIE	1.4047	3.0034	0.1511
SPBANDEB	0.0024	2.7531	0.0003
ILLIQUIDITY	-0.0325	-2.8814	-0.0342
RISK	0.1003	2.9452	0.0107
McFadden R-squared	0.7805		

IRELAND→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-1.7375	-2.3386	
IESPBAN	0.4744	2.4299	0.0460
IEPUB	1.8637	3.0118	0.1807
DEFIE	0.4884	2.9797	0.0474
IEBAN	0.0686	3.2286	0.0067
IEGOVDEB	1.3247	3.2064	0.1284
USP	3.3531	2.9637	0.3251
ILLIQUIDITY	-0.0033	-3.1283	-0.0003
RISK	0.1197	3.0635	0.0116
McFadden R-squared	0.7543		

PORTUGAL→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	-147.9653	-2.9226	
PTITBAN	14.0927	2.7931	1.2154
DEFPT	0.3866	3.1760	0.0333
UPT	2.0428	2.9199	0.1762
RATPT	1.7169	2.8993	0.1481
UIT	5.6041	3.0620	0.4833
PTPUB	2.7088	2.9514	0.2336
RATIT	2.5597	2.9842	0.2208
PTGOVDEB	1.5823	3.5154	0.1365
ILLIQUIDITY	-0.0909	-2.9923	-0.0078
RISK	0.3194	3.0041	0.0275
McFadden R-squared	0.6237		

ITALY→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	8.8944	2.9498	
ITPTBAN	4.9877	3.1441	0.3761
DEFIT	0.6928	2.7849	0.0523
UIT	1.1399	3.2571	0.0860
UPT	4.0633	2.7881	0.3064
ITHOUDEB	1.5715	2.7795	0.1185
RATIT	1.9716	2.9472	0.1487
ITGOVDEB	2.4741	3.1906	0.1866
ILLIQUIDITY	-0.0315	-2.9195	-0.0024
RISK	0.0861	2.9008	0.0065
McFadden R-squared	0.8147		

Notes: **CACXX** = Current-account-balance-to-GDP of country XX. **UXX** = Unemployment rate of country XX. **INFXX** = Inflation rate of country XX. **RATXX** = Credit rating scale of country XX. **DEFXX** = Government deficit-to-GDP of country XX. **XXGOVDEB** = Government debt-to-GDP of country XX. **XXBANDEB** = Bank debt-to-GDP of country XX**. XXNFIDEB** = Non-financial corporations debt-to-GDP of country XX. **XXHOUDEB** = Households debt-to-GDP of country XX. **XXBAN** = Foreign bank claims on banks debt-to-GDP of country XX. **XXPUB** = Foreign bank claims on government debt-to-GDP of country XX. **XXPRI** = Foreign bank claims on non-financial private debt-to-GDP of country XX. **XXYYBAN** = Percentage of country XX's foreign claims held by country YY's banks. **ILLIQUIDITY** = Advanced Economies Illiquidity Indicator. **RISK** = Global risk aversion indicator.

Table 10: Probit models augmented with interaction effects of illiquidity and global risk aversion

GREECE→IRELAND	Coefficient	z-Statistic	Marginal Effects
GRIEBAN	23.5953	3.4455	4.3752
GRGOVDEB	0.0680	2.7854	0.0298
UGR	0.2133	2.6301	0.0285
DEFIE	0.1009	2.9220	0.0186
IEBAN	0.0150	2.9074	0.0065
IEPRI	0.0256	2.7282	0.0076
GRBANDEB	0.2058	2.9095	0.0397
ILLIQUIDITY	-0.0157	-2.7570	-0.0029
RISK	0.3869	2.7691	0.0732
ILLIQUIDITY*RISK	-0.0016	-2.9548	-0.0002
McFadden R-squared	0.6703		

IRELAND→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-0.7870	-2.8131	
IEGRBAN	113.0662	4.1153	10.7852
IEPUB	1.7324	3.9368	0.1653
DEFIE	0.1104	3.1284	0.0105
ILLIQUIDITY	-0.0392	-2.8578	-0.0037
RISK	0.1903	2.9917	0.0181
ILLIQUIDITY*RISK	-0.0014	-2.8448	-0.0001
McFadden R-squared	0.7556		

GREECE→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	0.8253	2.8729	
GRITBAN	0.0869	2.9450	0.0221
INFGR	1.2045	2.9984	0.3059
UGR	0.1505	2.9989	0.0382
RATGR	0.0832	2.8394	0.0211
GRGOVDEB	0.2406	2.7983	0.0611
ILLIQUIDITY	-0.0035	-2.8771	-0.0009
RISK	0.0156	2.8396	0.0040
ILLIQUIDITY*RISK	-0.0001	-2.7235	-0.0000
McFadden R-squared	0.9253		

ITALY→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-139.6537	-2.8948	
ITGRBAN	5.2795	2.6594	0.3353
DEFIT	1.2835	2.8966	0.0815
ITBANDEB	0.1667	2.8997	0.0106
UIT	2.4613	2.8709	0.1563
RATGR	7.5683	2.6213	0.4806
ITPUB	2.1128	2.9185	0.1342
ITHOUDEB	5.7369	2.8391	0.3643
ILLIQUIDITY	-0.0465	-2.8391	-0.0030
RISK	0.1256	2.7770	0.0080
ILLIQUIDITY*RISK	-0.0020	-2.7185	-0.0001
McFadden R-squared	0.98458		

GREECE→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-1.9629	-2.7804	
GRPTBAN	11.5044	2.8344	0.5867
INFGR	1.6425	2.1751	0.0838
UGR	3.8496	2.7438	0.1963
GRGOVDEB	0.7791	3.4487	0.0397
RATPT	4.7224	3.6761	0.2408
GRNFIDEB	2.9453	3.6542	0.1502
GRPUB	1.4348	2.6407	0.0732
GRPRI	1.8503	3.2501	0.0944
ILLIQUIDITY	-0.0446	-3.0448	-0.0023
RISK	0.1608	2.9660	0.0082
ILLIQUIDITY*RISK	-0.0040	-2.9996	-0.0002
McFadden R-squared	0.9145		

PORTUGAL→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-98.3345	-4.2424	
PTGRBAN	6.2515	3.3940	0.4557
INFPT	3.4615	3.9577	0.2523
UPT	8.4237	4.3448	0.6141
DEFPT	0.4025	3.1006	0.0293
PTNFIDEB	1.3229	2.8243	0.0964
PTPUB	0.4540	3.5035	0.0331
PTBANDEB	0.8941	2.9129	0.0652
ILLIQUIDITY	-0.0409	-2.3609	-0.0030
RISK	0.0722	2.8961	0.0053
ILLIQUIDITY*RISK	-0.0009	-2.9009	-0.0001
McFadden R-squared	0.7796		

GREECE→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-4.7747	-2.8820	
GRSPBAN	7.3570	2.8343	0.2641
UGR	4.4935	2.8642	0.1613
GRGOVDEB	0.8714	2.8937	0.0313
DEFSP	0.3770	2.9386	0.0135
ILLIQUIDITY	-0.0340	-2.9636	-0.0012
RISK	0.1204	2.8689	0.0043
ILLIQUIDITY*RISK	-0.0037	-2.8946	-0.0001
McFadden R-squared	0.9189		

SPAIN→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-133.4032	-2.6721	
SPGRBAN	48.0733	2.8977	3.6103
SPBANDEB	0.3523	2.7975	0.0265
SPNFIDEB	0.1335	2.7378	0.0100
RATGR	1.6226	2.6639	0.1219
RATSP	6.8820	2.8622	0.5168
CACSP	-1.0735	-2.8260	-0.0806
SPPUB	13.6971	2.7289	1.0287
ILLIQUIDITY	-0.0227	-2.8999	-0.0017
RISK	0.0674	2.7969	0.0051
ILLIQUIDITY*RISK	-0.0120	-2.7933	-0.0009
McFadden R-squared	0.8598		

SPAIN→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-6.1759	-2.9709	
SPPTBAN	1.8959	2.9378	0.1204
SPNFIDEB	2.5278	3.1829	0.1605
UPT	12.1182	3.4206	0.7695
ILLIQUIDITY	-2.9458	3.0941	-0.1871
RISK	27.0826	2.8187	1.7197
ILLIQUIDITY*RISK	-11.5433	-2.9018	-0.7330
McFadden R-squared	0.8921		

PORTUGAL→SPAIN	Coefficient	z-Statistic	Marginal Effects
PTSPBAN	7.7094	2.7711	2.9615
DEFPT	0.6004	2.6083	0.2306
UPT	4.7650	2.8049	1.8304
INFPT	0.9275	2.8086	0.3563
RATPT	0.3013	2.8404	0.1158
USP	3.4507	2.7747	1.3255
SPGOVDEB	1.8672	2.7042	0.7173
ILLIQUIDITY	-0.0407	-2.8748	-0.0157
RISK	0.1038	1.0000	0.0399
ILLIQUIDITY*RISK	-0.0073	-2.7576	-0.0028
McFadden R-squared	0.9394		

SPAIN→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	-7.8759	-2.8789	
SPITBAN	0.2722	2.9515	0.0323
DEFSP	0.0469	2.8041	0.0056
USP	0.1102	2.9830	0.0131
SPGOVDEB	0.1689	2.8961	0.0200
CACSP	-0.4541	-2.9594	-0.0539
UIT	0.5804	2.7211	0.0689
ITPUB	0.7693	2.7787	0.0913
RATIT	0.2064	2.8270	0.0245
ILLIQUIDITY	-0.0011	-2.7465	-0.0001
RISK	0.0227	2.9698	0.0027
ILLIQUIDITY*RISK	-0.0002	-2.8462	-0.0000
McFadden R-squared	0.6963		

ITALY→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-24.2255	-2.6485	
ITSPBAN	4.2727	2.8469	0.7976
DEFIT	0.7387	2.7795	0.1379
ITBANDEB	0.2830	2.8049	0.0528
RATSP	9.2491	2.8278	1.7266
ITGOVDEB	2.1709	2.7124	0.4053
UIT	4.4292	2.8793	0.8268
ILLIQUIDITY	-0.2544	-2.9246	-0.0475
RISK	1.4454	3.0037	0.2698
ILLIQUIDITY*RISK	-0.0125	-2.5035	-0.0023
McFadden R-squared	0.8102		

ITALY→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	82.2322	2.3371	
ITIEBAN	6.9281	3.1314	0.7399
DEFIT	0.2186	2.5255	0.0233
ITBANDEB	0.3538	2.5514	0.0378
UIT	1.6961	2.5952	0.1811
RATIE	2.2563	2.8836	0.2410
ITHOUDEB	0.9061	2.6073	0.0968
ITGOVDEB	0.7067	2.7409	0.0755
ILLIQUIDITY	-0.0622	-2.7906	-0.0066
RISK	0.2433	3.0338	0.0260
ILLIQUIDITY*RISK	-0.0007	-2.8542	-0.0001
McFadden R-squared	0.8371		

IRELAND→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	-65.6892	-2.0990	
IEITBAN	0.1135	2.6682	0.0040
IEPUB	17.6200	2.8038	0.6167
DEFIE	4.2196	2.9312	0.1477
INFIE	3.6974	2.8652	0.1294
ILLIQUIDITY	-1.3091	-2.9690	-0.0458
RISK	4.1643	2.8726	0.1458
ILLIQUIDITY*RISK	-0.0981	-2.9314	-0.0034
McFadden R-squared	0.8772		

PORTUGAL→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	-6.6985	3.6928	
PTIEBAN	10.3235	3.1335	1.0324
DEFPT	1.6691	0.0000	0.0958
UPT	0.5162	2.5632	0.0296
INFPT	0.2950	2.9878	0.0169
RATPT	0.8876	2.9959	0.0510
UIE	0.1004	3.1005	0.0058
IEGOVDEB	0.4597	2.9984	0.0264
ILLIQUIDITY	-0.0056	-2.7563	-0.0003
RISK	0.1971	2.6398	0.0113
ILLIQUIDITY*RISK	-0.0083	-2.9720	-0.0005
McFadden R-squared	0.8604		

IRELAND→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-118.8472	-3.2886	
IEPTBAN	1.0555	2.9751	0.0918
IEPUB	0.5752	2.6464	0.0501
DEFIE	0.9057	3.1952	0.0788
UIE	10.6073	2.8882	0.9231
IEBAN	0.1076	2.4596	0.0094
IEGOVDEB	2.4621	3.5270	0.2143
UPT	2.9267	3.0600	0.2547
CACPT	-6.8436	-3.6064	-0.5955
ILLIQUIDITY	-0.1494	-2.9520	-0.0130
RISK	0.2691	3.3571	0.0234
ILLIQUIDITY*RISK	-0.0027	-2.9301	-0.0002
McFadden R-squared	0.9381		

SPAIN→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	-160.2748	-3.2919	
SPIEBAN	27.3400	3.2206	1.7890
DEFSP	0.0652	2.7753	0.0043
USP	7.7428	4.0389	0.5067
SPBAN	1.7368	3.7409	0.1136
SPGOVDEB	1.2431	3.1171	0.0813
CACSP	-0.4528	-2.7532	-0.0296
UIE	4.2187	3.3761	0.2761
SPBANDEB	0.2971	4.3054	0.0194
ILLIQUIDITY	-0.1626	-2.3981	-0.0106
RISK	0.9122	5.3047	0.0597
ILLIQUIDITY*RISK	-0.0102	-3.8380	-0.0007
McFadden R-squared	0.8185		

IRELAND→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-2.9136	-2.4948	
IESPBAN	0.4348	2.4494	0.0356
IEPUB	1.9811	3.2824	0.1624
DEFIE	0.5216	2.5944	0.0427
IEBAN	0.0953	2.9238	0.0078
IEGOVDEB	1.4513	2.6871	0.1189
USP	3.6563	1.9027	0.2996
ILLIQUIDITY	-0.0282	-2.4532	-0.0023
RISK	0.0348	1.8166	0.0029
ILLIQUIDITY*RISK	-0.0079	-2.4870	-0.0007
McFadden R-squared	0.7602		

PORTUGAL→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	-192.1364	-2.9390	
PTITBAN	15.6532	2.8760	1.0189
DEFPT	0.8965	3.0498	0.0584
UPT	2.8767	2.9824	0.1873
RATPT	2.7005	2.9560	0.1758
UIT	5.7894	2.9993	0.3769
PTPUB	2.3480	2.9197	0.1528
RATIT	4.9180	3.2217	0.3201
PTGOVDEB	2.4724	3.1112	0.1609
ILLIQUIDITY	-0.2711	-2.9826	-0.0176
RISK	0.2658	2.9810	0.0173
ILLIQUIDITY*RISK	-0.0073	-2.9965	-0.0005
McFadden R-squared	0.6933		

ITALY→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	9.4879	2.9944	
ITPTBAN	4.8134	3.0914	0.5776
DEFIT	0.6826	2.9371	0.0819
UIT	1.0259	3.1291	0.1231
UPT	5.9393	2.9317	0.7127
ITHOUDEB	1.7152	2.9918	0.2058
RATIT	1.9833	2.9580	0.2380
ITGOVDEB	2.7263	3.0274	0.3272
ILLIQUIDITY	-0.0356	-2.9722	-0.0043
RISK	0.0825	2.9454	0.0099
ILLIQUIDITY*RISK	-0.0064	-2.9441	-0.0008
McFadden R-squared	0.8498		

Notes: **CACXX** = Current-account-balance-to-GDP of country XX. **UXX** = Unemployment rate of country XX. **INFXX** = Inflation rate of country XX. **RATXX** = Credit rating scale of country XX. **DEFXX** = Government deficit-to-GDP of country XX. **XXGOVDEB** = Government debt-to-GDP of country XX. **XXBANDEB** = Bank debt-to-GDP of country XX**. XXNFIDEB** = Non-financial corporations debt-to-GDP of country XX. **XXHOUDEB** = Households debt-to-GDP of country XX. **XXBAN** = Foreign bank claims on banks debt-to-GDP of country XX. **XXPUB** = Foreign bank claims on government debt-to-GDP of country XX. **XXPRI** = Foreign bank claims on non-financial private debt-to-GDP of country XX. **XXYYBAN** = Percentage of country XX's foreign claims held by country YY's banks. **ILLIQUIDITY** = Advanced Economies Illiquidity Indicator. **RISK** = Global risk aversion indicator. **ILLIQUIDITY * RISK** = Advanced Economies Illiquidity Indicator * Global risk aversion indicator

Table 11: Probit models augmented with interaction effects of debt and global risk aversion

GREECE→IRELAND	Coefficient	z-Statistic	Marginal Effects
GRIEBAN	26.1321	2.8482	5.1146
GRGOVDEB	0.1371	2.7250	0.0635
UGR	0.2053	2.9278	0.0289
DEFIE	0.1657	2.9708	0.0322
IEBAN	0.0436	2.8221	0.0200
IEPRI	0.0024	2.8839	0.0008
GRBANDEB	0.2482	2.8958	0.0505
ILLIQUIDITY	-0.0194	-2.9361	-0.0038
RISK	0.1102	2.8793	0.0220
GRGOVDEB*RISK	0.0007	2.9547	0.0001
GRBANDEB*RISK	0.0014	2.9872	0.0002
McFadden R-squared	0.7156		

IRELAND→GREECE

GREECE→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	4.0323	2.8085	
GRITBAN	0.2434	2.9450	0.0319
INFGR	2.8003	2.9984	0.3668
UGR	2.2612	2.8321	0.2962
RATGR	0.6349	2.7614	0.0832
GRGOVDEB	1.0164	2.8017	0.1332
ILLIQUIDITY	-0.0038	-2.7434	-0.0005
RISK	0.0098	2.9023	0.0013
GRGOVDEB*RISK	0.0004	2.8465	0.0001
McFadden R-squared	0.9334		

ITALY→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-218.8510	-3.1572	
ITGRBAN	6.2075	2.8936	0.2439
DEFIT	1.0658	2.9923	0.0419
ITBANDEB	0.5207	3.0009	0.0205
UIT	1.9507	2.9239	0.0766
RATGR	8.1958	2.9175	0.3220
ITPUB	4.2216	2.8196	0.1659
ITHOUDEB	6.6419	2.8349	0.2610
ILLIQUIDITY	-0.0295	-2.8694	-0.0012
RISK	0.0246	2.8342	0.0010
ITBANDEB*RISK	0.0097	2.9640	0.0004
ITHOUDEB*RISK	0.0343	2.9360	0.0013
McFadden R-squared	0.8420		

GREECE→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-0.8210	-2.8631	
GRPTBAN	5.3045	2.7215	0.3464
INFGR	1.1741	2.9495	0.0767
UGR	1.7474	2.1759	0.1141
GRGOVDEB	0.6883	2.7245	0.0449
RATPT	3.1797	3.4502	0.2076
GRNFIDEB	2.2512	3.6761	0.1470
GRPUB	0.6634	3.6560	0.0433
GRPRI	0.8689	2.6382	0.0567
ILLIQUIDITY	-0.0129	-3.2482	-0.0008
RISK	0.3938	3.0447	0.0257
GRGOVDEB*RISK	0.0102	2.8212	0.0007
GRNFIDEB*RISK	0.0254	2.8373	0.0017
McFadden R-squared	0.9092		

PORTUGAL→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-92.3684	-3.0251	
PTGRBAN	7.8104	2.8345	0.5666
INFPT	3.8489	2.7558	0.2792
UPT	9.6748	2.9537	0.7019
DEFPT	0.5297	2.8814	0.0384
PTNFIDEB	1.9707	2.9980	0.1430
PTPUB	0.9473	2.8980	0.0687
PTBANDEB	1.2869	2.9220	0.0934
ILLIQUIDITY	-0.0028	-2.8419	-0.0002
RISK	1.1396	2.7933	0.0827
PTNFIDEB*RISK	0.0105	2.9105	0.0008
PTBANDEB*RISK	0.0023	2.9023	0.0002
McFadden R-squared	0.7835		

GREECE→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-5.0171	-2.8343	
GRSPBAN	7.7244	2.8642	0.3191
UGR	4.4237	2.8937	0.1827
GRGOVDEB	0.9856	2.9386	0.0407
DEFSP	0.3339	2.9636	0.0138
ILLIQUIDITY	-0.0248	-2.9683	-0.0010
RISK	0.1190	2.8734	0.0049
GRGOVDEB*RISK	0.0113	2.7051	0.0005
McFadden R-squared	0.9191		

SPAIN→GREECE	Coefficient	z-Statistic	Marginal Effects
Constant	-147.1025	-2.9815	
SPGRBAN	34.1620	2.8170	1.2264
SPBANDEB	0.8098	2.6889	0.0291
SPNFIDEB	0.2188	2.8121	0.0079
RATGR	0.8091	2.8767	0.0290
RATSP	5.4020	2.9121	0.1939
CACSP	-1.0917	-2.9050	-0.0392
SPPUB	13.6215	2.9823	0.4890
ILLIQUIDITY	-0.0101	-2.7439	-0.0004
RISK	0.0534	2.9712	0.0019
SPBANDEB*RISK	0.0067	2.8740	0.0002
SPNFIDEB*RISK	0.0502	2.7157	0.0018
McFadden R-squared	0.8527		

SPAIN→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-3.0668	-2.9779	
SPPTBAN	4.4542	3.0909	0.2729
SPNFIDEB	4.4566	3.1771	0.2731
UPT	9.8237	3.0487	0.6019
ILLIQUIDITY	-1.7886	-3.5291	-0.1096
RISK	48.1312	2.8300	2.9490
SPNFIDEB*RISK	2.1486	2.86362	0.1316
McFadden R-squared	0.9085		

PORTUGAL→SPAIN	Coefficient	z-Statistic	Marginal Effects
PTSPBAN	5.8442	2.9890	1.9169
DEFPT	0.6282	2.8755	0.2061
UPT	4.0670	2.7679	1.3340
INFPT	0.5967	2.8085	0.1957
RATPT	0.3381	2.8399	0.1109
USP	3.2509	2.7502	1.0663
SPGOVDEB	3.1669	2.9459	1.0388
ILLIQUIDITY	-0.0528	-2.7747	-0.0173
RISK	0.0132	2.8017	0.0043
SPGOVDEB*RISK	0.0526	2.8884	0.0173
McFadden R-squared	0.9371		

SPAIN→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	-9.2232	-3.1085	
SPITBAN	0.2364	2.7060	0.0242
DEFSP	0.0461	2.8983	0.0047
USP	0.0526	3.0837	0.0054
SPGOVDEB	0.1591	2.9814	0.0163
CACSP	-0.1482	-2.9189	-0.0152
UIT	0.1063	2.7702	0.0109
ITPUB	0.7448	2.7975	0.0763
RATIT	0.2248	2.8174	0.0230
ILLIQUIDITY	-0.0032	-2.8430	-0.0003
RISK	0.0806	2.9688	0.0082
SPGOVDEB*RISK	0.0017	2.7494	0.0002
McFadden R-squared	0.6931		

ITALY→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-23.4151	-2.8255	
ITSPBAN	4.0697	2.7258	0.6206
DEFIT	0.5268	2.7953	0.0803
ITBANDEB	0.3240	2.8536	0.0494
RATSP	11.4740	2.9918	1.7498
ITGOVDEB	0.3107	2.7960	0.0474
UIT	8.6447	2.8793	1.3183
ILLIQUIDITY	-0.0164	-2.7211	-0.0025
RISK	0.1790	2.7349	0.0273
ITBANDEB*RISK	0.0385	2.6338	0.0059
ITGOVDEB*RISK	0.0526	2.7794	0.0080
McFadden R-squared	0.8037		

ITALY→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	118.3209	2.4732	
ITIEBAN	8.9647	3.0125	0.6096
DEFIT	0.3025	2.6341	0.0206
ITBANDEB	0.5934	2.5167	0.0404
UIT	1.8147	2.6342	0.1234
RATIE	2.9803	2.9612	0.2027
ITHOUDEB	1.7801	2.9134	0.1210
ITGOVDEB	1.2230	2.8917	0.0832
ILLIQUIDITY	-0.0571	-2.9651	-0.0039
RISK	0.1799	2.9978	0.0122
ITBANDEB*RISK	0.0033	2.7292	0.0002
ITHOUDEB*RISK	0.0294	2.8348	0.0020
ITGOVDEB*RISK	0.2772	2.8621	0.0188
McFadden R-squared	0.8666		

IRELAND→ITALY

PORTUGAL→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	-1.5065	-2.9571	
PTIEBAN	21.4191	2.8138	1.0881
DEFPT	1.4999	2.9577	0.0762
UPT	1.4097	2.7668	0.0716
INFPT	0.6823	2.7912	0.0347
RATPT	0.6496	2.9867	0.0330
UIE	0.1899	2.8189	0.0096
IEGOVDEB	0.0597	2.7308	0.0030
ILLIQUIDITY	-0.0035	-2.8756	-0.0002
RISK	0.0642	2.7851	0.0033
IEGOVDEB*RISK	0.0204	2.9420	0.0010
McFadden R-squared	0.8625		

IRELAND→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	-186.6826	-3.0768	
IEPTBAN	1.4352	2.9748	0.0630
IEPUB	0.2057	2.5495	0.0090
DEFIE	0.7069	2.8705	0.0310
UIE	9.5615	2.8409	0.4194
IEBAN	0.2544	2.7862	0.0112
IEGOVDEB	3.5751	2.9601	0.1568
UPT	6.1889	2.9445	0.2715
CACPT	-8.7021	-2.8029	-0.3817
ILLIQUIDITY	-0.0785	-3.0334	-0.0034
RISK	2.1348	2.8776	0.0936
IEGOVDEB*RISK	0.0065	2.9339	0.0003
McFadden R-squared	0.9473		

SPAIN→IRELAND	Coefficient	z-Statistic	Marginal Effects
Constant	-189.5535	-3.0946	
SPIEBAN	36.2526	2.2719	1.9483
DEFSP	0.1706	2.6497	0.0092
USP	5.7001	2.6318	0.3063
SPBAN	2.6322	2.9051	0.1415
SPGOVDEB	1.0803	3.5426	0.0581
CACSP	-3.4889	-2.9300	-0.1875
UIE	4.1121	2.9397	0.2210
SPBANDEB	1.0823	2.9051	0.0582
ILLIQUIDITY	-0.0055	-2.9251	-0.0003
RISK	2.2899	2.8661	0.1231
SPGOVDEB*RISK	0.1624	2.8770	0.0087
SPBANDEB*RISK	0.0649	2.9137	0.0035
McFadden R-squared	0.8521		

IRELAND→SPAIN	Coefficient	z-Statistic	Marginal Effects
Constant	-4.8900	-3.2812	
IESPBAN	0.3969	2.1135	0.0330
IEPUB	2.0831	3.0723	0.1731
DEFIE	0.5105	2.9818	0.0424
IEBAN	0.0516	2.6992	0.0043
IEGOVDEB	1.8076	3.1842	0.1502
USP	3.3103	2.4573	0.2750
ILLIQUIDITY	-0.0021	-3.0995	-0.0002
RISK	0.3683	2.9280	0.0306
IEGOVDEB*RISK	0.0069	2.8504	0.0006
McFadden R-squared	0.7597		

PORTUGAL→ITALY	Coefficient	z-Statistic	Marginal Effects
Constant	-142.0596	-3.1061	
PTITBAN	13.9833	3.0329	1.2282
DEFPT	0.3997	2.3091	0.0351
UPT	2.1166	3.1246	0.1859
RATPT	1.6867	2.7040	0.1481
UIT	5.5688	3.0308	0.4891
PTPUB	2.7625	2.1477	0.2426
RATIT	2.5447	2.9578	0.2235
PTGOVDEB	1.6348	2.8920	0.1436
ILLIQUIDITY	-0.0890	-2.8689	-0.0078
RISK	0.5368	2.7151	0.0471
PTGOVDEB*RISK	0.0032	2.9356	0.0003
McFadden R-squared	0.7058		

ITALY→PORTUGAL	Coefficient	z-Statistic	Marginal Effects
Constant	7.0257	3.0728	
ITPTBAN	4.7296	3.0848	0.4555
DEFIT	0.7624	2.8326	0.0734
UIT	1.1926	2.7801	0.1149
UPT	4.3506	2.9067	0.4190
ITHOUDEB	1.5826	2.8433	0.1524
RATIT	1.8940	3.0324	0.1824
ITGOVDEB	2.6257	3.0768	0.2529
ILLIQUIDITY	-0.0315	-2.9764	-0.0030
RISK	0.0879	2.9544	0.0085
ITHOUDEB*RISK	0.1548	2.8449	0.0149
ITGOVDEB*RISK	0.0315	2.7433	0.0030
McFadden R-squared	0.8593		

Notes: **CACXX** = Current-account-balance-to-GDP of country XX. **UXX** = Unemployment rate of country XX. **INFXX** = Inflation rate of country XX. **RATXX** = Credit rating scale of country XX. **DEFXX** = Government deficit-to-GDP of country XX. **XXGOVDEB** = Government debt-to-GDP of country XX. **XXBANDEB** = Bank debt-to-GDP of country XX**. XXNFIDEB** = Non-financial corporations debt-to-GDP of country XX. **XXHOUDEB** = Households debt-to-GDP of country XX. **XXBAN** = Foreign bank claims on banks debt-to-GDP of country XX. **XXPUB** = Foreign bank claims on government debt-to-GDP of country XX. **XXPRI** = Foreign bank claims on non-financial private debt-to-GDP of country XX. **XXYYBAN** = Percentage of country XX's foreign claims held by country YY's banks. **ILLIQUIDITY** = Advanced Economies Illiquidity Indicator. **RISK** = Global risk aversion indicator. **ILLIQUIDITY * RISK** = Advanced Economies Illiquidity Indicator * Global risk aversion indicator. **XXGOVDEB * RISK** = Government debt-to-GDP of country XX * Global risk aversion indicato**r. XXBANDEB * RISK** = Bank debt-to-GDP of country XX * Global risk aversion indicator. **XXNFIDEB * RISK** = Non-financial corporations debt-to-GDP of country XX * Global risk aversion indicator. **XXHOUDEB * RISK** = Households debt-to-GDP of country XX * Global risk aversion indicator.