Interdependence between Sovereign and Bank CDS Spreads in Eurozone during the European Debt Crisis - The PSI Effect

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Abstract

This paper examines the changes in the interdependence between sovereign and bank credit risk, that were noticed, after the announcement of the voluntary exchange program of Greek bonds, with the participation of the private sector (Private Sector Involvement - PSI). More precisely, we investigate the progress of the credit default swaps (CDS) of eight eurozone countries and of twenty-one banking institutions, for the period of January 2009 to May 2014. We divide the sample into two sub-periods, based on the announcement of the program. We apply Hsiao's methodology (1981), in order to ascertain the causality which is observed between the CDS series and potential changes in their relationship, due to the implementation of the PSI. We identify limited causality relations between countries and banks of the sample examined, in the second sub-period, while the size of the interaction is reduced in the same period. After developing a Difference-in-Difference model, we confirm the weakening of causal relationships between the CDS series studied, for the period, after the announcement of the PSI. Our results suggest that the implementation of the PSI has contributed to the limitation of the interdependence between the CDS spreads of the sovereigns and banks in the period that follows.

Keywords: CDS spreads, PSI, sovereign credit risk, bank credit risk, debt crisis, contagion, eurozone

JEL Classification: F34, F42, G28, H12, H63

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1. Introduction

The global financial crisis of 2007, began in the US, and quickly expanded to the other side of the Atlantic -particularly in the European area- causing a systemic crisis in European banks. This was caused by the dramatic reduction of the liquidity in the interbank money market. Especially, countries such as Spain and Ireland, received intense pressure from the credit crunch created, due to the fact, that their banking system was significantly supported by the real estate market. The collapse of the housing market and the further significant decline in economic activity, resulted in the bankruptcy of many of the countries' banking institutions, since banks had granted huge mortgage loans. Hence, this dramatic increase of private debt turned into a fiscal crisis for these countries.

This crisis has highlighted the critical and unique role of the banking sector to ensure the stability and development, not only of the global financial system, but, that of individual countries as well. Banks, which in the years before the crisis, had taken considerable risks in order to achieve higher profits, are now faced with new conditions and challenges. Their profitability declined significantly, and many encountered record losses that obliged them to turn to government bailout programs, so in order to ensure their operation.

Specifically, after the 2007 financial crisis, concerns about the health of the European Union (EU) banking system escalated as a result of the direct exposure of European banks to troubled sovereigns. These are reinforced by a weaker growth outlook for the EU region, and, stressed global funding markets. Furthermore, as the new regulatory standards are put into effect, European banks and EU lawmakers started to realize the great challenges banks now face in order to comply with the increased capital and liquidity requirements. Against the backdrop of continuing financial market turbulence, falling lending volume, compounded by exposures to distressed sovereigns, banks find it even more difficult to remain profitable. This brings into the forefront the issue of bankruptcy. Consequently, stronger emphasis is put on the importance of economic support from the government sector to the banking sector[1] in order to meet their obligations, and, to prevent possible bankruptcy. This action could cause a domino effect, with unpredictable consequences, for the banking sector, and the European economy as a whole.

On the other hand, the immense liquidity problems that several countries of the eurozone faced, obliged countries, such as, Greece, Portugal, and Italy, which had significant

[1] The different government assistance programs for the financial sector are divided into four categories, according to Alter and Schuler, (2012): "capital injections, guarantees for banks liabilities, asset support programs, and deposit insurance".

fiscal problems over a long period of time, to resort to the help of international organizations (International Monetary Fund -IMF, European Central Bank-ECB). This was done in order for these countries to be able to service their debt, and to rescue the banks from a systemic collapse. These conditions, combined with the unfavorable situation of the financial sector, lacked the necessary funds that would allow for its reversal, therefore making it necessary for the need to absorb public funds. For this purpose, countries provided unlimited liquidity, which in turn, restricted their fiscal condition.

As far as the banks were concerned, and especially the European ones, they came under strong pressure, due to the rising sovereign risk. This was mainly because of the huge amount of public debt, which they held in their portfolios. This, combined with the lack of liquidity that also prevailed, and, with the strong dependence on the Central Bank, caused an immediate increase in financing costs. Furthermore, the holding of public debt resulted in the deterioration of the balance sheets of banks which held government bonds, as well as, the flight of significant amount of capital owing to the collapse of the investors' confidence in the banking sector.

Many studies (Ejsing & Lemke (2009), Bolton & Jeanne (2011), Acharya et al. (2011), Alter & Schueler (2010), among others) have underlined the interdependence between sovereign and bank credit risk, which significantly increased, especially, during the recent euro area sovereign debt crisis of 2009. Moreover, they have observed various transmission channels of credit risk between sovereigns and banks. While at the beginning of the debt crisis we noted the transmission of credit risk from banks to the states, after the disclosure of the new data on the amount of the Greek debt (Nov 2009), the previous relationship was reversed. Subsequently, we observe a credit risk transfer from the states to the financial sector.

More precisely, the possibility of Greece's bankruptcy would directly affect banks of other countries that keep significant amounts of Greek debt in their possession. This leads to the rise of the bank credit risk and the sovereign credit risk of the respective countries, since they will have to support their national banking system in order to avoid a contingent collapse. In addition to this, the increasing risk, due to a possible insolvency of Greek banks, is transferred to foreign creditors who have invested in the Greek banking system, and thus, causing a constant increase in the probability of transmitting the risk to foreign countries.

As a result of the above situation, we see a rapid growth in the yields of government bonds, as well as in the spreads of sovereign and bank CDS (Credit Default Swaps). A number of important measures, have therefore, been adopted by European political and economic leaders. Among these, is the program of the voluntary exchange of Greek bonds, with the participation of the private sector (Private Sector Involvement -PSI- 10/2011), and the banks' capability for direct capitalization by the European Stability Mechanism (ESM - 06/2012)[2].

The official aim of the PSI was the relief of the Greek debt (reducing the debt to GDP ratio to 120% by 2020[3]), with the transfer of part of this debt to the private sector[4], and consequently to many private financial institutions which held a significant amount of public debt in their portfolios. This was done, in order to ensure the sustainability of the Greek economy and to guarantee its position in the eurozone[5]. The PSI is perceived as a message to the private sector, for the need for rational and safer management of funds. Trust in investment in government bonds weakened. Today, the challenge for policy-makers, is not just to ensure that the debt becomes sustainable, but, to do so in a way that prevents future financial crises.

The purpose of our paper is to empirically investigate the relationship between the sovereign and bank credit risk for the period of January 2009 to May 2014. Our study extends the previous research on the interdependence between sovereign and bank credit risk, by considering new factors in the analysis that have not been used before. In particular, we examine the impact of the implementation of the PSI program, in the interdependence between sovereign and bank credit risk, observing the fluctuation of credit default derivatives of eight eurozone[6] countries and twenty-one banking institutions[7] of these countries. To do so, we consider two sub-periods, the period before (01/01/2009-26/10/2011), and the period after the

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[2] Other measures were the unlimited purchase from the ECB of government bonds from the secondary market for the countries having recourse to the support mechanism (09/2012), the impairment of private deposits in Cyprus (03/2013), and the significant reduction of the interest rates by the ECB (09/2014), which aimed primarily at reducing the credit risk of countries and banks.

[3] Euro Summit Statement on October 26, 2011.

[4] The statement of the Hellenic Ministry of Finance on February 24, 2012, specifies the terms of the PSI program. The new bonds would necessarily be governed by English law. Specifically, "the exchange offers and/or consent solicitations will permit private sector holders to exchange bonds selected to participate in PSI for:

(i) new bonds to be issued by the Hellenic Republic on the PSI settlement date having a face amount equal to 31.5% of the face amount of their exchanged bonds,

(ii) European Financial Stability Facility notes with a maturity date of two years or less from the PSI settlement date and having a face amount equal to 15% of the face amount of their exchanged bonds, and

(iii) detachable GDP-linked securities issued by the Hellenic Republic having a notional amount equal to the face amount of each holder's new bonds.

On the PSI settlement date, the Hellenic Republic will also deliver short-term EFSF notes in discharge of all unpaid interest accrued up to 24 February 2012 on exchanged bonds. The Hellenic Republic will not, however, deliver any EFSF notes to holders in the United States of America, who will instead be paid the cash proceeds realized from the sale of the EFSF notes they would otherwise have received. "

[5] It is the first time, where a eurozone country fails to meet its obligations, and there is now a possibility of defaulting under certain circumstances.

[6,7] The countries and the banking institutions of the sample are referred in Table 1.

announcement of the PSI (27/10/2011-30/05/2014). Furthermore, we intend to see whether this program could be used in the future in similar crises, so in order to reduce contagion and systemic risk.

This paper contributes to the existing literature on the contagion effects between sovereign and bank default risk, by examining to what extent a program such as the PSI, may have altered the interdependence between sovereign and bank credit risk -by employing the respective CDS spreads. We present evidence that the implementation of the PSI has contributed to the restriction of the interdependence between CDS spreads of governments and banks in the period following the program. Consequently, we infer that the PSI is a process, which could be used in the future, by competent authorities, in order to reduce contagion and systemic risk.

The remainder of the paper is structured as follows. Section 2, reviews the existing literature on the relationship between sovereign and bank credit risk. Section 3, describes the data used in the empirical analysis, while Section 4, presents the methodology employed. Section 5, discusses the empirical results of this research. Finally, Section 6, summarizes the main conclusions.

2. Literature Review

There is vast literature concerning the cross-country transmission of credit risk. In the last decade, a large part of this literature has concentrated on the interdependence between different sovereign markets. Kalbaska and Gatowski (2012), examine the transmission of credit risk between nine EU countries, with the use of CDS spreads for the period from 08/2005 until 09/2010. They argue that the interdependencies between countries have increased significantly with the spread of the global financial crisis, compared to the pre-crisis period. Finally, they conclude that countries facing the most serious economic problems in the eurozone - Portugal, Italy, Ireland, Greece, Spain (known as PIIGS) - have a lesser ability to cause contagion, with respect to the powerful countries of the European Union.

By studying the co-movement of sovereign CDS spreads, after the onset of the Greek crisis of October 2009, Andenmatten and Brill (2011) look for the existence of contagion, by means of a bivariate control, for thirty-nine countries worldwide. They detect the existence of interdependence, as well as contagion, among European countries. Gentile and Giordano (2012), study the contagion of credit risk after the collapse of Lehman Brothers (2008), and during the European debt crisis, drawing on data from the bond and stock markets. They infer that causality has changed with the occurrence of the crises, in relation to periods prior to these, thus, finding the contagion of credit risk among eight different European countries

After the global crisis of 2007 broke out, when the role of the banking system was catalytic, empirical research in cross-country studies has focused on the relationship between sovereign and bank credit risk. The results of these studies converge, that this relation has gone beyond the simple interaction, and, has developed into interdependence and contagion[8] between countries and banks.

Lahmann (2012), identifies the interdependence between sovereign and bank credit risk, by analyzing the relation between sovereign and bank CDS spreads at a global level, for the period of October 2005 to April 2011. He shows that, after the outbreak of the debt crisis, interactions between CDS have intensified, while the effect of bank risk to sovereign is stronger. This indicates that countries are exposed to the contingent liabilities of the banking sector, due to, the huge financial support being provided. In their study, Ejsing and Lemke (2011), investigate the default risk of governments and banks of ten Euro area countries. They identify a significant interdependence between public and private risk, by using a common risk factor (iTraxx index of non-financial CDS premia). After the date of the announcement of the bank rescue packages, which was considered as a structural break point, the bank CDS spreads decreased, while the corresponding sovereign CDS spreads increased.

Following a similar line of research, Tamakoshi and Hamori (2013) analyze the causality observed between the index of CDS of the banking sector of the eurozone, and the sovereign CDS spreads of Greece, for the period of 2008 to 2011. Before the debt crisis in Europe, they identify the transmission of credit risk only by bank CDS to CDS spreads of Greece. During the crisis, however, the situation is different as there is a significant influence of Greek sovereign CDS spreads to bank CDS.

Many authors, such as Alter and Schuler (2011) among them emphasize -by employing CDS spreads of six eurozone countries and their domestic banks- that in the period before the bailout of financial institutions by the states, the sovereign credit risk was influenced mainly by the banks' credit risk. However, the respective results were reversed in the period after the bailout of the banking sector. In another study Acharya, Drechsler and Schnabl (2011), examine the effect of bidirectional feedback between sovereign and bank credit risk for the period 2007

[8] The World Bank regards that contagion is observed, when the transmission of shocks between the countries increase in times of crisis, with respect to the corresponding transmissions in tranquil periods (www.econ.worldbank.org).

to 2011 of the eurozone countries. Initially, they observe the banks' exposure to the risk of foreign countries. Consequently, they find that the greatest concern stems from their cross-border exposure to the risk of the private sector. In addition, they provide empirical evidence that the government rescue packages towards the banking sector, reinforce the interconnection between bank credit risk and the corresponding sovereign risk, while there is a rise in sovereign CDS spreads, and, a reduction in bank CDS, respectively.

Dieckmann and Plank (2010), underline a private-to-public risk transfer in eighteen European countries, which have taken stringent measures during the crisis, in order to restore financial stability. They point out that the risk transfer was greater for the countries which were more exposed to their financial system, in the pre-crisis period, and, for those countries which were members of the Economic and Monetary Union (EMU). In contrast, Demirguc-Kunt and Huizinga (2010), highlight the reversal risk channel, by studying an international sample of countries and banks. They conclude that bank CDS spreads rose remarkably in the countries with weak fiscal conditions. This occurs because these countries cannot provide adequate assistance in order to bail out their financial sector.

3. Data

In order to study the interdependence observed in the relationship between the sovereign and bank default risk in our sample, we use, as a financial instrument, the daily prices of the senior unsecured sovereign CDS spreads on 5-year government bonds -considered as those with higher liquidity[9]-, as well as, the respective senior unsecured bank CDS spreads. The sample period ranges from January 1st, 2009 until May 30th, 2014. The higher the value of CDS spreads, the less likelihood, a country or a banking institution, is able to meet its obligations.

The CDS premiums are considered in the current literature, as an effective measure among other credit risk measures[10]. A CDS is a security contract between two parties, the buyer and the seller. The ultimate aim of a CDS is to transfer the credit risk from the buyer, who purchases the contract, by paying a fixed fee -risk premium (CDS spread)- to the seller of the contract. The seller, is in turn compensated for the risk undertaken, in the event of failure of the buyer to fulfill the debt obligations. The seller, is obliged to compensate the buyer, if a credit event occurs, at the nominal value of the assets which he holds, or, to pay the difference

[9] Hull, Nelken & White, (2004).
[10] Fontana & Scheicher, (2010).

between the nominal value, and the market value. The bankruptcy of a country, or of a banking institution, is one such event. The CDS spreads are expressed in basis points.

We draw daily data on CDS spreads, from Thomson Reuters Datastream (CMA- Credit Market Analysis) and Bloomberg, in order to capture the dynamic changes occurring in the relationship under study. Our sample consists of these countries in the eurozone, experiencing major debt problems during the recent financial crisis, and, which are considered as the weak link, and the source of destabilization of the economic situation in the euro area. More specifically, these countries are Portugal (PT), Italy (IT), Ireland (IR), Greece (GR), and Spain (SP), known by the acronym PIIGS. Moreover, in our sample, we also include, the Netherlands (NL), France (FR) and Germany (DE). These countries possessed in their portfolios major shares of PIIGS' debt. The selection of the sample of banks in each country, is based, both, on their total assets, and on the availability of the data for the period under review. Table 1 presents the selected banking institutions.

The data is transformed into natural logarithms, so as not to have a great impact from the reaction of the PIIGS. Therefore, an equal variation in CDS spreads of Greece and the Netherlands, will not have the same magnitude. In our sample, taking the logarithmic values[11] becomes important because of the wide variations in the values of spreads for some countries and banks, during the period of analysis. Turning now to bank risk premiums, we weigh the bank CDS spreads of our sample by using their total liabilities for each year. We do this in order to calculate the index of bank CDS spreads for each country examined.

To understand the possible change in the interaction among sovereign and bank credit risk of our sample, as a result of the PSI program, we divide the reporting period into two sub-periods. Thus, the structural point is determined exogenously, October 27, 2011 is the day, after the announcement of the decision of the European Summit, for the implementation of the voluntary exchange program of Greek bonds, with the participation of the private sector.

Figures 1 and 2 below, illustrate the evolution of the examined logged CDS series during the sample period. The red vertical line indicates the date that separates our sample. In these figures, we observe that the Greek spreads rose to exceptional levels, particularly during the period of the PSI program. This was because uncertainty was pervasive in the derivatives' market (PSI completed on 25/04/12). We see similar variation in the government CDS spreads of the other countries in our sample during the period of the program. From the study of the two

[11] Forte & Pena, (2009).

figures, we note that CDS spreads of most countries and banks, during the relevant period, were close to their maximum levels.

Figure 1: Daily Sovereign CDS spreads

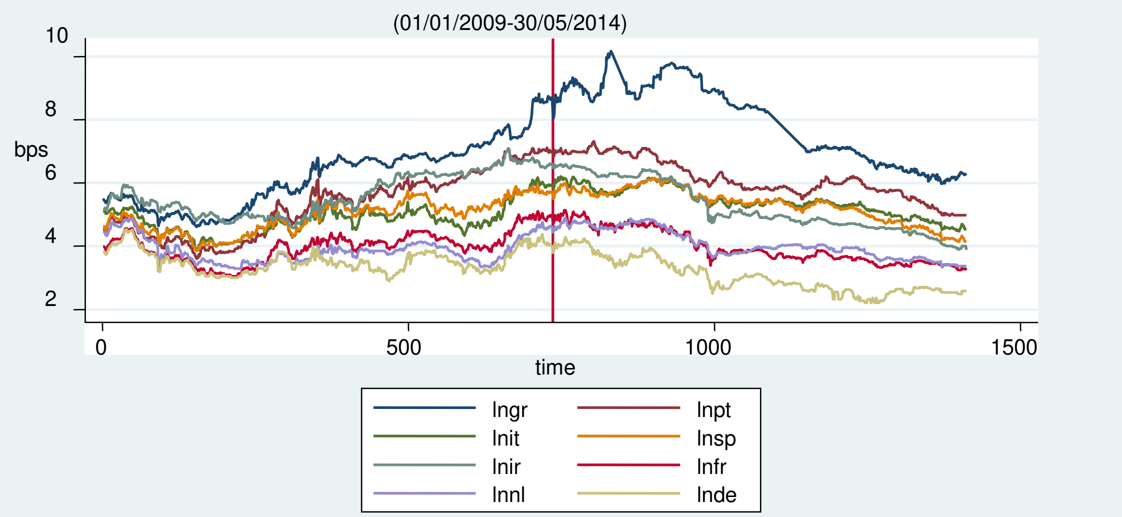
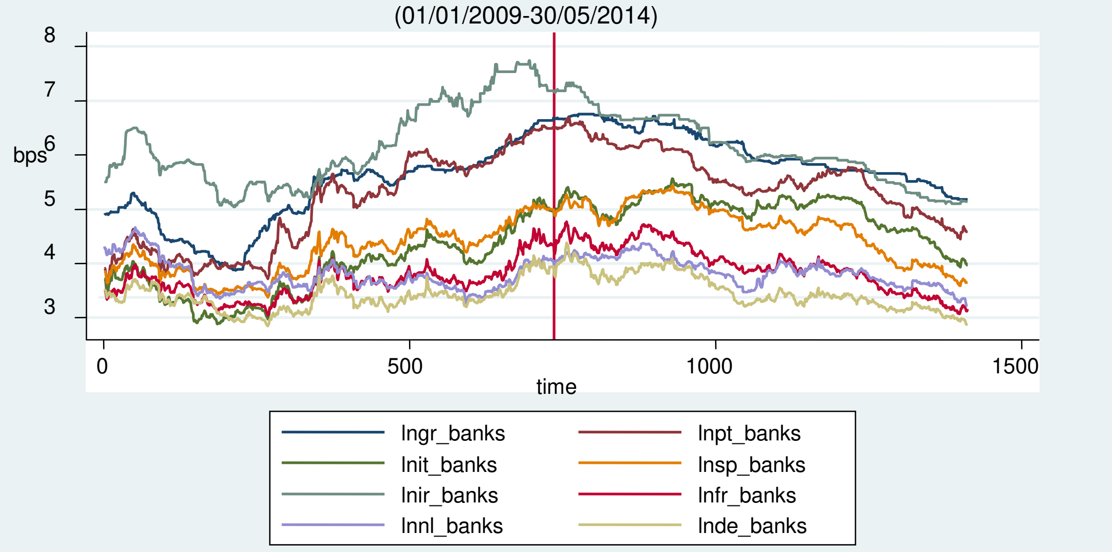


Figure 2: Daily Bank CDS spreads



Tables 2-5 display the summary statistics of sovereign and bank CDS spreads of our sample. We observe, that the average of the spreads increase significantly during the second period, after the announcement of the PSI, except for those of Ireland, Germany and the Irish banks. The average sovereign CDS of our sample for the first period is 253.38bps, while for the second period, it is 845.76bps, which is mainly due to the surge of Greek risk premium. The corresponding averages without Greece, are 160.93bps and 207.86. The bank CDS spreads averages are 173.87bps and 221.03bps, for the first and for the second period respectively.

The results are similar, in terms of standard deviation, of the time series in the two study periods. This fact is an indication of intensified volatility, uncertainty, and risk in the second study period. Whereas, for the Irish, the Portuguese and the Dutch banks, the standard deviation is reduced during the second period.

Overall, we observe that the sovereign CDS spreads are at a higher level than that of the corresponding bank CDS for the two sub-periods, with the exception of the Irish banks for both sub-periods, and the German banks in the second period. This reflects that there is higher government credit risk, during the European debt crisis, in relation to that of the banking sector. Similar are the results of the standard deviation, except for that of Irish banks.

Regarding the high prices of kurtosis, we conclude that the CDS spreads change remarkably, quite often, while this is indicative of the increased probability of observing outliers, particularly in the first period, and, that there is a total rise of credit risk. We notice positive skewness for all time series, except for the Italian bank CDS in the second period. Consequently, there are a few high outliers in relation to the large population of low prices, which is an indicative element of the turmoil observed, especially, in the first period.

Observing the results of pair-wise correlations of sovereign and bank CDS spreads, in their logarithmic first-differences, in Table 6, we find significant correlations, greater than 0.3 for all concerned relations -with the exception of Greece and Ireland- during the second period. In addition, we conclude that there is a considerable reduction in the correlations between CDS spreads during the second period for the entire sample.

4. Methodology

4.1. Econometric specification

In order to examine the interdependence, which is possibly observed, between sovereign and banking sector credit spreads in our sample, we do not apply the known Granger-causality tests, which can be found broadly in the relevant literature. We conduct our analysis by employing Hsiao's methodology (1981)[12], which is based on the Granger method of causality (1969), and on the use of the Akaike's Final Prediction Error (FPE) criterion (1969)[13].

[12] The same methodology was followed in the study of Gomez-Puig and Sosvilla-Rivero (2013), entitled "Granger Causality in Peripheral EMU Debt Markets: A Dynamic Approach", in which they examined the

Hsiao considers that the hardest part, in a multiple autoregressive process, is defining the maximum number of lags. Thus, the method which he proposes, allows each variable to be inserted in the examined equation with a different lag, according to the minimum FPE criterion. This approach aims to reduce the number of the parameters under estimation, so in order to balance the bias and inefficiency problems of the parameterized model. This option, according to Hsiao, is equivalent to applying an F-test with varying significance levels.

We seek to ascertain the existence and the direction of causality, both, before and after, the announcement of the PSI program. The methodology is as follows:

Let Y and X two stationary variables in levels (i.e. I(0)).

1. First, we consider Y as a one-dimensional autoregressive process:

$$Y_t = \gamma_0 + \sum_{i=1}^{K} \phi_i Y_{t-i} + \varepsilon_t \qquad \textbf{(1)}$$

We calculate the FPEs, with the number of lags ranging from 1 to K. We choose the lag k, where 1≤k≤K, which implies the minimum FPE:

$$FPE_Y(\kappa,0)=(T+\kappa+1)/(T-\kappa-1)*RSS/T^{14,15} \qquad \textbf{(2)}$$

2. Then, we regard Y as a controlled variable with lag equal to k, and X as a manipulated variable:

$$Y_t = \gamma_0 + \sum_{i=1}^{K} \phi_i Y_{t-i} + \sum_{j=1}^{\Lambda} p_j X_{t-j} + \varepsilon_t \qquad \textbf{(3)}$$

We re-calculate the FPEs of Y, changing the lags of X from 1 to L, and determine the lag λ, where 1≤λ≤Λ, which corresponds to the minimum value of FPE:

$$FPE_Y(\kappa,\lambda)=(T+\kappa+\lambda+1)/(T-\kappa-\lambda-1)*RSS/T \qquad \textbf{(4)}$$

3. Subsequently, we compare the FPE calculated in step 1, ($FPE_Y(k,0)$), with the corresponding FPE calculated in step 2, ($FPE_Y(k,\lambda)$). If ($FPE_Y(k,0)$)>($FPE_Y(k,\lambda)$), then the optimal model for the

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interdependence between the eurozone countries, by using the 10-year government bonds, for the period 1999-2010.

[13] According to Hsiao this methodology "is used to impose restrictions in order to capture empirical regularities which remain hidden to standard procedures."

[14] **T**: the total number of the observations, and **RSS**: Residual Sum of Squares of regression (1).

[15] The FPEs are calculated on the assumption that the residuals are white noise.

prediction of Y is that comprising k lags of Y and λ of X. In this case, we conclude that X causes Y. Otherwise, if $(FPE_Y(k,0))<(FPE_Y(k,\lambda))$, then Y is calculated as a one-dimensional autoregressive process.

4. We repeat the process considering X as a controlled variable and Y as a manipulated one.

If our variables Y and X have a unit root in levels, but, they are stationary in the first-differences (i.e. are integrated of order one, I(1)), we repeat the above procedure, but now, in order to ascertain, whether there is a causal relationship between the ΔY and ΔX. If our variables are not cointegrated, we consider the following equations:

$$\Delta Y_t = \gamma_0 + \sum_{i=1}^{K} \varphi_i \Delta Y_{t-i} + \varepsilon_t \quad \textbf{(5)}$$

$$\Delta Y_t = \gamma_0 + \sum_{i=1}^{K} \varphi_i \Delta Y_{t-i} + \sum_{j=1}^{\Lambda} p_j \Delta X_{t-j} + \varepsilon_t \quad \textbf{(6)}$$

Finally, if we find out, that the under consideration time series, is linked with a common stochastic trend (cointegrated), then in the equations (5) and (6) we have to include an error correction term (ECT)[16]:

$$\Delta Y_t = \gamma_0 + \beta ECT_{t-1} + \sum_{i=1}^{K} \varphi_i \Delta Y_{t-i} + \varepsilon_t \quad \textbf{(7)}$$

$$\Delta Y_t = \gamma_0 + \beta ECT_{t-1} + \sum_{i=1}^{K} \varphi_i \Delta Y_{t-i} + \sum_{j=1}^{\Lambda} p_j \Delta X_{t-j} + \varepsilon_t \quad \textbf{(8)}$$

Hence, with the help of the minimum calculated FPEs, we determine the difference FPE(k,0) - FPE(k,λ) for the time series, in which we observed causality, both before and after the announcement of the PSI, in order to find possible differentiation in its magnitude. From the size of the change of causality, we are able to see if there is interaction, and the relative size of it, between sovereign and bank default risk -as a consequence of the PSI program- assessing the impact of this program on CDS spreads of our sample.

[16] ECT: the error-correction term from the cointegrating equation $Y_t=\alpha+\beta X_t$.

4.2. Bivariate cointegration analysis

In order to apply Hsiao's methodology described above, with the purpose of ascertaining the existence of interdependence between the sovereign, and, the corresponding bank CDS spreads, we have to, initially, test if the time series is stationary by means of the known unit root tests for both periods. We run the Phillips-Perron (PP[17]) test, the Augmented Dickey-Fuller (ADF[18]) test, and Kwiatkowski-Phillips-Schmidt-Shin (KPSS[19]) test. In the KPSS test, unlike the others, the null hypothesis checks the existence of stationarity. We consider that the time series has a unit root, when at least two of the above tests, demonstrate the existence of a unit root at a 5% significance level.

If the series has a unit root, in order to achieve stationarity, we receive the logarithmic first-differences, and we repeat the unit root tests. If we conclude, after the second line of tests, that the time series is integrated of order one, i.e. I(1), then we check the existence of cointegration. We use the Johansen's tests (1995), concretely the trace test, and the maximum eigenvalue test, in order to estimate the number of cointegrated relationships. The time series is cointegrated, if at least one of the tests proves the existence of cointegration at a 5% significance level.

We select the number of lags, which we use for conducting the cointegration tests, based on the information criterion of Hannan-Quinn (HQIC). The selection of the appropriate lag length should be performed very carefully, as there is the risk of biased estimation of the cointegrating vector[20].

When performing the trace test, the null hypothesis (H_0) is $r \leq r_0$ for $r_0=0,1,...n-1$ where n is the number of variables. Therefore, it examines that the maximum number of cointegrating vectors are r_0, versus the alternative (H_1) which are more than r_0, H_1: $r_0<r\leq n$. In our study, in which we examine two variables (n = 2) -sovereign and bank CDS series-, we consecutively check for $r_0=0$ and $r_0=1$. The control stops at the value of r_0 that H_o is accepted.

Regarding the application of the maximum eigenvalue tests, the H_o hypothesis is the same. However, the H_1 assumes that there are exact r_0+1 cointegrating vectors. It should be noted that, if, after performing these tests, we find that $r_0=n$, this means that the variables are stationary in levels (i.e. I(0)). We choose, during these tests, the possibility of linear trend, which is more plausible in reflecting the generating mechanism of the data.

[17] Phillips & Perron, (1988).
[18] Dickey & Fuller, (1979).
[19] Kwiatkowski, Phillips, Schmidt & Shin, (1992).
[20] Jacobson, (1995).

4.3. Difference-in-Difference model

The Difference-in-Difference (DID) method, that we develop, aims to detect the change of the effect of bank CDS premiums to the respective sovereign, before, and after, the announcement of the PSI program, as well as, the corresponding change of the effect of sovereign CDS in bank CDS spreads. For this purpose, initially, we form a dummy variable, TD (Timedummy), which takes the value 0 for the period before the announcement, and, the value 1 for the period afterwards. The coefficient of the variable TD expresses the increase or decrease, on average, of the short-term impact of the change in the explanatory variable to the response variable, after the notification of the program, which we are considering.

Subsequently, we create a new dummy variable, INT (Interaction), in order to observe the change in the coefficient of the independent variable after the announcement of the PSI program. The coefficient of the dummy variable INT (slope) reflects the change of the effect observed, (if it is statistically significant), after the announcement of the program, from the independent to the dependent variable. Specifically, we examine the following equation:

$$\Delta Y_{it} = \delta_0 + \delta_1 * TD + \delta_2 * INT + \delta_3 \Delta X_{it} + u_{it} \quad \textbf{(9)}$$

$$\text{where: } INT = TD * \Delta X_{i\,t} \quad \textbf{(10)}$$

The examination of the above equation assumes that our variables are not cointegrated. We check the time series of our sample, for the entire study period, by the Johansen's cointegration tests described above. If we find the existence of a long-term equilibrium relationship between the time series, we adjust the equation (9), so that we include the error-correction term. The new equation that we study in this case is the following:

$$\Delta Y_{it} = \delta_0 + \delta_1 * TD + \delta_2 * INT + \delta_3 \Delta X_{it} + \delta_4 Z_{t-1} + u_{it} \quad \textbf{(11)}$$

$$\text{where: } Z_t : \text{the residual of } Y_{it} = \gamma_0 + \gamma_1 * TD + \gamma_3 X_{it} + u_{it} \quad \textbf{(12)}$$

We allow the introduction of the dummy variable TD in equation (12), in order to shift the constant term from the cointegrating equation. Thus, the cointegrating equation changes, after the date of the announcement of the PSI, once we have included the TD variable in the long-term relationship. Therefore, if the resulting residuals are distributed normally, this means that there is cointegration with varying equilibrium. The coefficient γ_1 denotes the change to the constant term of the long-term relationship, that we are considering. If it is positive, this means that the constant term of the long-term equation changes, in the value of γ_1. We conclude, that both variables deviate further between them, hence, the distance of the time series increases on average, after the announcement of the PSI. In this case, the equilibrium point Y_{it}, is on average higher for various values of X_{it}. The results are the opposite if γ_1 is negative.

5. Empirical Results

5.1. Interdependence between CDS spreads

In order to apply Hsiao's methodology for testing the causality, as described in sub-section 4.1., we examine the CDS series for the existence of stationarity in levels -in log prices- for both sub-periods, by applying ADF, PP and KPSS tests. We note, that all the series have a unit root. By repeating this process, using at this time, the first-differences of the log prices of the CDS spreads, we infer that our series are stationary. Audit results from the unit root tests, which we performed, are presented in detail in Tables 7-10.

Tables 11 and 12, analytically display, the results of Johansen's trace and maximum eigenvalue tests, after controlling for the existence of cointegration, for both sub-periods. The lag length is specified according to the information criterion of Hannan-Quinn (HQIC), separately, for each sub-period. We allow the existence of a linear trend in the data (in levels), while the cointegrating equations may be stationary around a non-zero mean. The countries, where a long-run relationship is observed, between the sovereign and the banking sector credit spreads in the first period, are Greece, Portugal, Spain, Ireland and France. On the contrary, the CDS series for Italy, the Netherlands and Germany diverge in the long-term. The results are different in the second period, as we find the existence of one cointegrating relation, only, between Spain's sovereign CDS spreads and Spanish bank CDS spreads ($r = 1$).

After conducting the necessary tests, we can proceed to examine the possible interrelation between sovereign and bank credit risk. Tables 13 and 14, present the results after calculating the FPEs, which are estimated based on equations (3) and (4), in the case that the series are not cointegrated, and based on equations (5) and (6), if there is a long-run relationship. Therefore, we include the error-correction term[21].

During the first period, we find the existence of bidirectional causality between CDS spreads for all countries and banks in the sample, with the exception of, the Portuguese and Irish

[21] We specify the maximum number of lags K equal to 25. Hsiao, in his study (1981) defines this number equals 15, but he uses quarterly data in his research.

banks, which do not affect the CDS of the respective countries. Therefore, in a total of fourteen possible causal relationships, causality is not detected, in only, two of the cases.

During the second period, after the announcement of the PSI, we observe a limitation of causal relations from sixteen to ten. More precisely, we do not find causality from the Portuguese and Italian banks to Portugal and Italy, respectively. Moreover, there is no interaction between the credit risk of the Netherlands and the Dutch banks, and of Germany with its own banks.

It is only in the Portuguese banks' CDS spreads, that we note the absence of causality to the respective sovereign CDS, in both sub-periods. On the contrary, we detect interaction between sovereign and bank credit risk for Greece, Spain and France, in both sub-periods.

Subsequently, in order to determine a possible variation in the size of causality -in the relations in which we found causality in the two periods-, we compute the difference of the minimum FPEs identified in Steps 1 and 2, FPE(k,0)-FPE(k,λ). By studying the results shown in Table 15, we infer that after the implementation of the PSI program, there is a reduction in the influence of Greek and Spanish bank CDS spreads on sovereign CDS of Greece and Spain, respectively. Similar are the results, concerning the effect of sovereign CDS of Greece, Portugal, Italy, Spain and Ireland to the respective bank CDS spreads. However, we find opposite results for France and French banks, in which there is an increase in the interdependence between them. Interpreting this result, this is probably due to the fact that French banks kept in their portfolios a large amount of Greek bonds during the implementation of the PSI, resulting in the strengthening of bank credit risk, and, its interaction with sovereign credit risk.

5.2. Difference-in-Difference results

Afterwards, we examine how the causality varies between CDS spreads, after the announcement of the implementation of the PSI, but, with a different methodology in relation to sub-section 5.1.. Our aim is to verify the results of the interdependence between sovereign and bank CDS, that we have already found, by applying Hsiao's methodology.

Initially, we define the cointegrated time series during the period from 01/01/2009 until 30/05/2014. We find the existence of a long-term equilibrium between sovereign CDS spreads of Portugal, Italy, Spain and Ireland, and the respective bank CDS. Table 16, presents the results obtained from the study, of both, the short-term and the long-term interdependencies of the sovereign and bank CDS spreads of the sample -with the Difference-in-Difference methodology- after assessing the equations (9) and (11), respectively.

By determining the coefficient of the dummy variable INT (Interaction) for each relation between CDS, we note the effect of a change (by one unit) of bank CDS spreads (sovereign CDS spreads) -after the announcement of the PSI- to the respective sovereign CDS spreads (bank CDS spreads). Since, the coefficient of INT is not statistically significant, we conclude that the effect of the independent variable to the corresponding equation, that we examine, has not changed. The bold letters in Table 16, show the coefficients for the countries in which long-term relation between the series, is observed.

We note, that in all cases, in which the coefficient of the dummy variable INT is statistically significant, there is a reduction in the influence of both bank CDS spreads to the respective countries, and vice versa. Specifically, we find that the effect of Greek, Portuguese, Spanish, Dutch and German bank CDS is limited to the government CDS spreads. There is also, a restriction of the effect of sovereign CDS of Greece, Portugal, Ireland, France and Germany in the corresponding bank CDS, in the period after the notification of the PSI program. For Greece, Portugal, and Germany, the interdependence between the CDS is reduced in both directions.

6. Conclusion

In the eurozone, the recent dramatic debt crisis has afflicted many countries, as a result of the global financial crisis that preceded it. This has led to the need for a bailout of many banking institutions, by European states, so as to avoid a collapse of the financial sector. This debt crisis has a direct effect on the notable growth of the sovereign credit risk.

The interdependence, between sovereign and bank default risk, has been extensively studied in the international literature of recent years. However, in our study, we focus on the development of this relationship, during the European debt crisis, by examining the CDS spreads of eight eurozone countries and of twenty-one banking institutions. We try to assess possible effects of this relationship, after the announcement of the voluntary exchange program of Greek bonds, with the participation of the private sector, which was announced at the Euro Summit of October 26, 2011. This program constitutes an innovation for the conservative eurozone, and is treated with extreme caution, by the international markets.

We study the period of 01/01/2009 to 30/05/2014. We divide the whole period into two sub-periods, with a structural point, the announcement of the PSI. By using Hsiao's methodology, and a Difference-in-Difference model, we examine the causality between the CDS spreads of the banks and the states. Based on the results obtained by calculating the FPEs, we infer that the interdependence between the CDS series in the second period, is restricted. Considering, at this time, the differences of the minimum FPEs, we find that the magnitude of the interactions has decreased in seven cases, while having increased, in only two cases. In particular, the causality has been enhanced between the CDS of France and French banks, in both directions.

Similar are the results, after the assessment of the Difference-in-Difference model, concerning the size of the interactions, after the announcement of the PSI. We note a decline in the size, in ten out of the sixteen possible relations, in which the coefficient of the dummy variable INT is statistically significant, hence, we do not find an increase of the size in any relation.

It becomes imperative, the need for the undertaking of initiatives, by political and economic leaders of the eurozone, to aim to reduce the interdependence between sovereign and bank credit risk. This fact will contribute, not only, in strengthening the stability of the financial system, but, in improving the financial conditions of the European countries which are facing serious economic problems. As part of these initiatives, we conclude in our study, that the implementation of the PSI, has contributed to the limitation of the interdependence between CDS spreads of sovereigns and banks, in the period that follows the program.

In future research, we aim to extend our analysis by examining the interdependence between the credit risk of Greece and the other eurozone countries, and the banking institutions of the sample, independently, both before, and after, the announcement of the PSI. This should be very interesting, as many people consider the fiscal situation of Greece as the source of all evil in the eurozone. Furthermore, we will attempt to study the interdependence between the CDS spreads of the eurozone countries and banks, during the European debt crisis, into sub-periods, which will be determined endogenously by the data, based on the known structural break tests. We believe, that this approach will bring about remarkable findings.

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Tables

Table 1: The sample of banking institutions

	Banking Institutions
GR_Banks	National Bank of Greece
	EFG Eurobank Ergasias SA
	Alpha Bank AE
PT_Banks	Banco Espirito Santo SA
	Banco Commercial Portugues SA
IT_Banks	Mediobanca SpA
	Banca Popolare di Milano
	Banca Monte dei Paschi Siena
SP_Banks	Banco de Sabadell SA
	Banco Bilbao Vizcaya Argentaria SA
	Banco Popular Espanol SA
IR_Banks	Bank of Ireland
FR_Banks	Natixis
	BNP Paribas SA
	Credit Agricole SA
NL_Banks	Cooperatieve Centrale Raiffeisen Boerenleenbank B.A (Rabobank)
	F Van Lanschot Bankiers NY
DE_Banks	Commerzbank AG
	Deutsche Bank AG
	IKB Deutsche Industriebank AG
	Bayerische Landesbank

Note: We weigh the banks in order to form the index of bank CDS spreads for each country, based on their total liabilities for each year.

Table 2: Summary statistics of the sovereign CDS spreads for the period 01/01/2009-26/10/2011.

Variable	Obs	Mean(b.p)	Std. Dev.	Min(b.p)	Max(b.p)	Skewness	Kyrtosis
GR	735	900.471	1168.948	100.270	6751.790	2.992	12.401
PT	735	320.484	304.391	37.000	1227.890	1.368	3.986
IT	735	141.667	79.053	48.000	482.041	1.908	6.734
SP	735	158.266	76.903	47.000	378.816	0.606	2.539
IR	735	356.871	237.855	96.925	1191.158	0.888	2.814
FR	735	60.537	29.287	21.000	164.931	1.197	4.483
NL	735	51.936	23.631	26.490	130.000	1.499	4.550
DE	735	36.745	14.862	17.960	92.500	1.418	4.950

Table 3: Summary statistics of the bank CDS spreads for the period 01/01/2009-26/10/2011.

Variable	Obs	Mean(b.p)	Std. Dev.	Min(b.p)	Max(b.p)	Skewness	Kyrtosis
GR_Banks	735	250.207	173.340	48.115	797.883	1.239	4.354
PT_Banks	735	218.023	178.768	37.444	690.088	0.926	2.874
IT_Banks	735	56.251	35.253	17.944	183.644	1.496	5.087
SP_Banks	735	72.697	33.529	29.288	165.428	0.849	3.117
IR_Banks	735	677.749	567.483	155.000	2298.981	1.233	3.397
FR_Banks	735	40.567	14.588	21.063	103.983	1.726	6.475
NL_Banks	735	45.384	15.751	25.653	106.039	1.605	5.184
DE_Banks	735	30.077	8.167	17.303	63.035	1.322	5.046

Table 4: Summary statistics of the sovereign CDS spreads for the period 27/10/2011-30/05/2014.

Variable	Obs	Mean(b.p)	Std. Dev.	Min(b.p)	Max(b.p)	Skewness	Kyrtosis
GR	598	5311.117	5274.033	391.635	25960.760	1.153	3.898
PT	677	557.908	348.214	143.950	1521.450	0.814	2.214
IT	677	249.677	106.216	87.730	498.660	0.593	2.324
SP	677	233.470	106.313	62.830	492.070	0.332	2.306
IR	677	261.511	212.750	48.650	729.190	0.842	2.089
FR	677	62.667	36.960	25.790	171.560	1.016	2.769
NL	677	65.117	30.514	28.460	133.840	0.749	2.103
DE	677	24.633	15.484	9.160	72.350	1.264	3.522

Table 5: Summary statistics of the bank CDS spreads for the period 27/10/2011-30/05/2014.

Variable	Obs	Mean(b.p)	Std. Dev.	Min(b.p)	Max(b.p)	Skewness	Kyrtosis
GR_Banks	677	476.853	214.784	177.048	859.490	0.411	1.708
PT_Banks	677	322.845	172.938	85.830	799.676	0.783	2.655
IT_Banks	677	152.059	45.783	51.001	259.746	-0.352	2.523
SP_Banks	677	121.020	50.464	36.179	230.199	0.119	2.095
IR_Banks	677	551.540	340.559	163.990	1530.140	1.037	3.369
FR_Banks	677	58.613	23.500	21.570	118.198	0.442	2.298
NL_Banks	677	49.499	12.447	25.274	79.465	0.326	2.332
DE_Banks	677	35.784	12.448	17.828	80.195	0.752	2.616

Table 6: Pair-wise correlations between the log-differences of sovereign and bank CDS spreads.

	1st period	**2nd period**
GR-GR_Banks	0.3283	0.0554
PT-PT_Banks	0.6361	0.3502
IT-IT_Banks	0.6607	0.6261
SP-SP_Banks	0.6691	0.5783
IR-IR_Banks	0.3103	0.1392
FR-FR_Banks	0.6190	0.5085
NL-NL_Banks	0.4254	0.3582
DE-DE_Banks	0.4991	0.3418

Note: The first period is from 01/01/2009 to 26/10/2011, and the second period is from 27/10/2011 to 30/05/2014.

Table 7: Unit root test results for sovereign CDS - 1st period

Sov CDS spreads	Log prices in levels			Log prices in first differences		
	PP	ADF	KPSS	PP	ADF	KPSS
GR	0.815	0.595	0.985*	-20.414*	-5.816*	0.0637
PT	-0.201	-0.045	1.210*	-21.563*	-6.994*	0.0496
IT	-1.124	-0.650	1.010*	-20.963*	-9.490*	0.0371
SP	-1.221	-0.985	0.924*	-22.400*	-6.466*	0.0343
IR	-0.735	-0.449	2.520*	-22.407*	-5.779*	0.0596
FR	-0.881	-0.813	1.050*	-21.086*	-11.299*	0.0483
NL	-1.518	-2.335*	1.510*	-20.885*	-5.634*	0.0521
DE	-2.079	-2.152**	1.250*	-24.097*	-9.765*	0.0330

Note: We examine the data for the existence of unit root by the tests PP, ADF, KPSS. The PP and ADF tests consider the null hypothesis of the existence of a unit root. On the contrary KPPS test examines the null hypothesis of stationarity. Period 1 ranges from 01/01/2009 to 26/10/2011. *, **, *** denote statistical significance at the 1%, 5%, and 10% level respectively.

Table 8: Unit root test results for bank CDS -1st period

Bank CDS spreads	Log prices in levels			Log prices in first differences		
	PP	ADF	KPSS	PP	ADF	KPSS
GR_Banks	0.866	-0.006	1.29*	-22.853*	-4.379*	0.2050
PT_Banks	-0.400	-0.530	1.13*	-20.926*	-6.594*	0.0526
IT_Banks	-0.179	-0.079	1.61*	-23.202*	-8.633*	0.0546
SP_Banks	-0.647	-0.736	1.33*	-20.362*	-5.930*	0.0460
IR_Banks	-0.646	-0.809	2.78*	-26.501*	-5.350*	0.1320*
FR_Banks	-1.172	-1.179	1.27*	-21.067*	-6.261*	0.0287
NL_Banks	-1.986	-1.765**	1.44*	-21.975*	-8.209*	0.0496
DE_Banks	-1.437	-1.190	1.46*	-22.294*	-5.942*	0.2050

Note: We examine the data for the existence of unit root by the tests PP, ADF, KPSS. The PP and ADF tests consider the null hypothesis of the existence of a unit root. On the contrary KPPS test examines the null hypothesis of stationarity. Period 1 ranges from 01/01/2009 to 26/10/2011. *, **, *** denote statistical significance at the 1%, 5%, and 10% level respectively.

Table 9: Unit root test results for sovereign CDS - 2nd period

Sov CDS spreads	Log prices in levels			Log prices in first differences		
	PP	ADF	KPSS	PP	ADF	KPSS
GR	0.735	0.372	-	-23.700*	3.886*	-
PT	-0.292	-0.460	1.07*	-20.676*	-6.402*	0.0749
IT	-0.554	0.073	0.586*	-21.765*	-6.424*	0.0269
SP	0.331	1.009	1.64*	-22.630*	-5.807*	0.0023
IR	-0.577	-0.374	1.44*	-27.288*	-5.973*	0.0699
FR	-1.398	-1.175	1.70*	-25.372*	-7.506*	0.0204
NL	-0.512	-0.336	0.845*	-22.687*	-5.924*	0.0737
DE	-1.612	-1.575***	1.55*	-25.068*	-6.377*	0.0302

Note: We examine the data for the existence of unit root by the tests PP, ADF, KPSS. The PP and ADF tests consider the null hypothesis of the existence of a unit root. On the contrary KPPS test examines the null hypothesis of stationarity. Period 2 ranges from 27/10/2011 to 30/05/2014. *, **, *** denote statistical significance at the 1%, 5%, and 10% level respectively.

Table 10: Unit root test results for bank CDS - 2nd period

Bank CDS spreads	Log prices in levels			Log prices in first differences		
	PP	ADF	KPSS	PP	ADF	KPSS
GR_Banks	0.503	0.211	0.537*	-31.107*	-6.272*	0.0615
PT_Banks	-0.226	-0.281	0.969*	-24.671*	-7.639*	0.1050
IT_Banks	0.453	0.104	1.860*	-20.027*	-5.358*	0.0526
SP_Banks	0.506	0.039	1.790*	-21.587*	-4.873*	0.0447
IR_Banks	-0.632	-0.713	0.559*	-25.737*	-5.430*	0.0670
FR_Banks	-0.321	0.062	0.815*	-20.659*	-5.670*	0.0281
NL_Banks	-0.302	-0.418	0.554*	-23.348*	-5.013*	0.0597
DE_Banks	-0.823	-0.704	0.521*	-20.990*	-5.509*	0.0312

Note: We examine the data for the existence of unit root by the tests PP, ADF, KPSS. The PP and ADF tests consider the null hypothesis of the existence of a unit root. On the contrary KPPS test examines the null hypothesis of stationarity. Period 2 ranges from 27/10/2011 to 30/05/2014. *, **, *** denote statistical significance at the 1%, 5%, and 10% level respectively.

Table 11: Bivariate cointegration tests for sovereign and bank CDS spreads -1st period

Variables	Lags	Trace test		Maximum Eigenvalue test	
		r=0	r=1	r=0	r=1
GR-GR_Banks	2	24.4985	0.0524*	24.4985	0.0524*
PT-PT_Banks	2	19.1222	0.4661*	18.6561	0.4661*
IT-IT_Banks	2	15.2359*	0.1347*	15.1012	0.1347*
SP-SP_Banks	3	25.7194	1.9372*	23.7822	1.9372*
IR-IR_Banks	2	36.1700	0.6809*	35.4891	0.6809*
FR-FR_Banks	2	15.4393	2.8144*	12.6250*	2.8144*
NL-NL_Banks	2	16.3120	4.7085	11.6035*	4.7085
DE-DE_Banks	2	14.8135*	5.3651	9.4484*	5.3651

Note: The table presents the results from the Johansen's trace and maximum eigenvalue tests for the period from 01/01/2009 to 26/10/2011. **r** denotes the null hypothesis. The control is performed at the 5% significance level.

Table 12: Bivariate cointegration tests for sovereign and bank CDS spreads-2nd period

Μεταβλητές	Lags	Trace test		Maximum eigenvalue	
		r=0	r=1	r=0	r=1
GR-GR_Banks	2	8.6006*	1.1925*	7.4081*	1.1925*
PT-PT_Banks	2	7.0834*	0.0073*	7.0761*	0.0073*
IT-IT_Banks	2	10.6103*	0.5055*	10.1048	0.5055*
SP-SP_Banks	2	19.5326	0.0595*	19.4731	0.0595*
IR-IR_Banks	4	5.7496*	0.2844*	5.4652*	0.2844*
FR-FR_Banks	2	8.1341*	0.5715*	7.5626*	0.5715*
NL-NL_Banks	2	9.2149*	0.1993*	9.0156*	0.1993*
DE-DE_Banks	2	7.2251*	1.5431*	5.6820*	1.5431*

Note: The table presents the results from the Johansen's trace and maximum eigenvalue tests for the period from 27/10/2011-30/05/2014. **r** denotes the null hypothesis. The control is performed at the 5% significance level.

Table 13: Causality test results - 1st period

Controlled variable	Manipulated variable	FPE (κ,0)	FPE (κ,λ)	Causality
GR	GR_Banks	0.00219825 (17,0)	0.00218050 (17,6)	YES
PT	PT_Banks	0.00303824 (18,0)	0.00304274 (18,9)	NO
IT	IT_Banks	0.00317368 (4,0)	0.00315099 (4,2)	YES
SP	SP_Banks	0.00303811 (18,0)	0.00301316 (18,2)	YES
IR	IR_Banks	0.00193204 (21,0)	0.00193724 (21,1)	NO
FR	FR_Banks	0.00220502 (6,0)	0.00217854 (6,3)	YES
NL	NL_Banks	0.00153231 (18,0)	0.00149575 (18,3)	YES
DE	DE_Banks	0.00315966 (7,0)	0.00313170 (7,1)	YES
GR_Banks	GR	0.00545950 (9,0)	0.00510580 (9,8)	YES
PT_Banks	PT	0.00138089 (20,0)	0.00130616 (20,3)	YES
IT_Banks	IT	0.00154072 (18,0)	0.00148333 (18,1)	YES
SP_Banks	SP	0.00104837 (13,0)	0.00101556 (13,4)	YES
IR_Banks	IR	0.00187015 (9,0)	0.00184361 (9,12)	YES
FR_Banks	FR	0.00141545 (4,0)	0.00140875 (4,6)	YES
NL_Banks	NL	0.00082783 (14,0)	0.00080951 (14,2)	YES
DE_Banks	DE	0.001218245 (5,0)	0.00117958 (5,24)	YES

Note: The numbers in the parentheses indicate the number of lags which give us the minimum FPEs for each variable. The first period is from 01/01/2009 to 26/10/2011.

Table 14: Causality test results - 2nd period

Controlled variable	Manipulated variable	FPE (κ,0)	FPE (κ,λ)	Causality
GR	GR_Banks	0.00410056 (17,0)	0.00409601 (17,9)	YES
PT	PT_Banks	0.00090126 (2,0)	0.00090725 (2,7)	NO
IT	IT_Banks	0.00122756 (2,0)	0.00122807 (2,1)	NO
SP	SP_Banks	0.00128335 (5,0)	0.00128255 (5,5)	YES
IR	IR_Banks	0.00086333 (17,0)	0.00084315 (17,5)	YES
FR	FR_Banks	0.00202591 (18,0)	0.00195837 (18,1)	YES
NL	NL_Banks	0.00068997 (1,0)	0.00069156 (1,1)	NO
DE	DE_Banks	0.00227849 (1,0)	0.00228224 (1,4)	NO
GR_Banks	GR	0.00039583 (2,0)	0.00035991 (2,20)	YES
PT_Banks	PT	0.00057258 (3,0)	0.00056300 (3,1)	YES
IT_Banks	IT	0.00062229 (1,0)	0.00061853 (1,1)	YES
SP_Banks	SP	0.00056732 (1,0)	0.00056099 (1,1)	YES
IR_Banks	IR	0.00036660 (3,0)	0.00036350 (3,3)	YES
FR_Banks	FR	0.00086041 (1,0)	0.00085228 (1,10)	YES
NL_Banks	NL	0.00061579 (1,0)	0.00061838 (1,1)	NO
DE_Banks	DE	0.00077597 (1,0)	0.00077930 (1,1)	NO

Note: The numbers in the parentheses indicate the number of lags which give us the minimum FPEs for each variable. The second period is from 27/11/2011 to 30/05/2014.

Table 15: Change of the interdependence

Controlled variable	Manipulated variable	1st period FPE (κ,0)- FPE (κ,λ)	2nd period FPE (κ,0)- FPE (κ,λ)	Interdependence
GR	GR_Banks	0.000017750	0.00000455	↓
SP	SP_Banks	0.000024950	0.00000080	↓
FR	FR_Banks	0.000026480	0.00006754	↑
GR_Banks	GR	0.000353700	0.00003592	↓
PT_Banks	PT	0.000074730	0.00000958	↓
IT_Banks	IT	0.000057390	0.00000376	↓
SP_Banks	SP	0.000032810	0.00000633	↓
IR_Banks	IR	0.000026540	0.00000310	↓
FR_Banks	FR	0.000006700	0.00000813	↑

Note: It presents the changes in causality for CDS time series which have a causal relationship in both periods. The first period is from 01/01/2009 to 26/10/2011, and the second period ranges from 27/10/2011 to 30/05/2014.

Table 16: Difference-in-Difference results

Controlled variable	Manipulated variable	Coefficient of INT	Interdependence
GR	GR_Banks	-0.4722166* (p=0.001)	↓
PT	PT_Banks	**-0.465363*** **(p=0.000)**	↓
IT	IT_Banks	**-0.0708884** **(p=0.268)**	-
SP	SP_Banks	**-0.267937*** **(p=0.000)**	↓
IR	IR_Banks	**-0.100114** **(p=0.229)**	-
FR	FR_Banks	0.0040141 (p=0.948)	-
NL	NL_Banks	-0.2081213* (p=0.001)	↓
DE	DE_Banks	-0.2190613*** (p=0.007)	↓
GR_Banks	GR	-0.1467038* (p=0.000)	↓
PT_Banks	PT	**-0.1611431*** **(p=0.000)**	↓
IT_Banks	IT	**-0.0104278** **(p=0.749)**	-
SP_Banks	SP	**-0.0079284** **(p=0.778)**	-
IR_Banks	IR	**-0.2038485** **(p=0.000)**	↓
FR_Banks	FR	-0.1651172* (p=0.000)	↓
NL_Banks	NL	0.0305242 (p=0.482)	-
DE_Banks	DE	-0.1105608* (p=0.000)	↓

Note: We regress the equation (7) and we receive the coefficients of the dummy variable INT. We test for the significance of these coefficients based on the p-values. *, **, *** denote statistical significance at the 1%, 5%, and 10% level respectively.