Testing for differences in sovereign spreads during the GFC using propensity matching estimators

ABSTRACT

This study uses propensity matching estimation to measure the effect of the Global Financial Crisis (GFC) on sovereign spreads using data from 43 countries. We estimate general underlying factor models allowing for multiple channels of contagion transmission then use estimates to select matching non-crisis benchmarks for nine portfolios of sovereign bonds. . We found no significant changes in spreads on portfolios of local currency emerging market debt during the GFC. Compared with conventional measures of contagion, propensity matching tests find that randomly selected counterfactuals based on common characteristics provide a stronger theoretical basis in explaining the difference in spreads between crisis and non crisis periods than traditional exogenous dating methods.

Keywords: Sovereign bonds, stepwise regression, contagion

I. Introduction

A critical problem in contagion modelling is subjectivity in dating crises. The power of any test for breaks or new channels in market linkages depends on how samples are set and different dating can lead to different results (Fry et al., 2011; Kose, 2011). Equally important is selecting a meaningful non-crisis benchmark, especially when the crisis dating approach is based on exogenously chosen events (Fry et al. (2011). Even where dates are fixed endogenously, variable selection may introduce bias (Baur, 2012).

Crisis dating methods fall into three categories: 1) Threshold- based methods where crisis dates are selected using extreme negative values at arbitrarily chosen quantiles[1] 2) Endogenous dating models that use Markov switching regimes and/or changes in time varying volatility for determining crisis dates[2] and 3) Exogenous dating in which the pre-crisis and crisis periods are divided into fixed timeframes by critical events.[3] Here we employ the crisis dating definition used by Dungey et al. (2010) in which an event or important policy change marks the beginning or the end of a crisis, falling into the third category.

Our main objective and contribution is to test for and measure contagion in sovereign debt markets using an approach that is more robust to exogenous crisis dating than standard approaches. We use propensity matching combined with an Average Treatment Effect on the Treated (ATET) method to correct possible sample selection effects. Propensity matching methods borrow from the methods of randomized controlled trials: at the first stage, general

[1] Examples in this category are: Bae, Karolyi, and Stulz (2003), Longin and Solnik (2001), Kaminsky, Lizondo, and Reinhart (1998) and Eichengreen, Rose, and Wyplosz (1996).
[2] See for example Ang and Bekaert (2002), Dungey, Milunovich, and Thorp (2010) and Phillips and Yu (2011).
[3] This is the most common approach and the body of literature is too large to be included. A comprehensive survey of the literature can be found in Fry et al. (2011).

factor models, including crisis dummies, are fitted to the whole sample; then a set of non-crisis observations most closely matching the factor values of the crisis sample observations are drawn, building an artificial but matching 'control' sample; and finally, the crisis and artificial non-crisis samples are compared in formal tests of shifts in spreads. Therefore, by allowing our crisis observations to act as 'treated' units, we can test whether the difference in spreads versus our 'non treated' benchmark is statistically significant. We apply this method to test for contagion in sovereign debt markets during the recent crises.

Our sample includes debt securities from 43 countries grouped into nine different portfolios: all economies debt, developed economies debt, emerging economies debt, Euro-currency debt, US dollar-denominated debt, local currency debt, local currency developed economy debt, local currency developed economy debt and the troubled European countries Portugal, Ireland, Italy, Greece, and Spain (PIIGS).

Although, there is no agreement on a single standardized factor model for sovereign spreads, there is consensus that country-specific fundamentals have been a major determinant of the variability of sovereign spreads during the financial crisis (GFC). In fact, several studies concur that prior to and during the first stage of the GFC in 2007-08, global risk aversion was driving sovereign spreads (Caceres et al., 2010; Sgherri and Zoli, 2009) but from 2009 onwards, country specific fundamentals became dominant. The perceived fragility of a country's financial sector and its potential to deplete public finances, signs of weak macroeconomic fundamentals and changes in trade variables became important to explaining differences in the sovereign spreads of Eurozone countries from the beginning of the global recession and into the recent sovereign debt crisis (Mody (2009); Schuknecht, Von Hagen, and Wolswijk (2009); Arghyrou and Kontonikas (2012)).

In the case of emerging market bonds, country fundamentals and proxies for risk aversion and liquidity are also major determinants of emerging markets spread variation (González-Rozada and Yeyati, 2008; Hilscher and Nosbusch, 2010; Remolona et al., 2007). This increase in the importance of country specific factors during the GFC stands in sharp contrast to previous crisis in emerging countries where spreads were driven mainly by global factors (Martinez et al., 2013; Mauro et al., 2002).[4] There are many possible sources of influence on sovereign spreads and it is natural to ask what factors, global, country-specific or latent, are the main drivers behind the changes in sovereign spreads.

Studies of contagion offer a taxonomy of transmission channels that can be used to categorize factors affecting spreads. Dungey and Martin (2007) classify the transmission channels into three categories: 1) Common or market shocks 2) Country specific shocks and 3) Latent or idiosyncratic shocks. In this paper we use the definitions of Giordano et al.(2013) in which common markets shocks are referred as "shift contagion", country-specific transmissions as "wake-up" contagion, and latent factor transmissions as "pure contagion". This three-way classification gives an economic interpretation of the factor model estimated here and allows an analysis of channels of volatility transmissions across sovereign debt markets. The main contribution in this paper is that we propose a novel framework to test for differences in spreads that correct biases found in conventional exogenous dating methods using propensity matching estimators. We show that the differences in spreads between crisis and non-crisis periods when obtained with traditional exogenous dating methodologies are grossly underestimated or overestimated when compared with results obtained with matching estimators. One key finding

[4] Other studies attribute the increase in global liquidity to the fall of emerging market spreads and a shift from common factors to specific factors during the GFC (Eichengreen et al., 2012; Hartelius et al., 2008). In the case of sovereign credit default swaps (CDS), which are common proxies for sovereign spreads, unobservable factors and risk aversion account for a large part of the observed variation (Coudert and Gex, 2008; Longstaff et al., 2011).

is that we found evidence that the portfolio of local currency emerging market debt did not exhibit any significant difference in spreads during the GFC as a whole, even under robust specifications and that the earlier phases of the GFC were not as contagious as previously thought at least in the case of sovereign debt.

This paper is divided as follows: Section II set out data sources and choice of variables for base regression models; section III outlines the proposed empirical model for measuring the differences between non-crisis and crisis conditions, section IV contains the summary of results, and section V concludes.

II. Common determinants of sovereign spreads

A. Variables and data description

In order to observe the effects that country specific and market factors had in sovereign spreads during the global financial crisis (GFC) we build factor models consistent with existing studies. However instead of CDS spreads, we model spreads of sovereign zero coupon bonds. The main reason for using actual spreads rather than CDS spreads is that CDS are priced using a risk-neutral framework, therefore default probabilities for CDS are much higher than those inferred from historical bond prices (Hull et al., 2012). By using actual spreads we address the issue of upward bias in the implied default probabilities described in section III.

For this paper, we used as our proxies for sovereign yields the Bloomberg fair market value zero coupon denominated sovereign bond curves (FMCZCB) for 43 countries (from which 23 are developed and 20 are emerging markets). These curves have the distinctive feature that

they are derived from actual bond prices and give a good approximation of what would be the theoretical price of other maturities that are not traded. The zero coupon curves are calculated for a different range of maturities using exactly the same base model created by Bloomberg, hence it is easy to aggregate prices into a country portfolio as well as observe differences in spreads relative to the US FMCZCB for different maturities. This feature allows aggregation by market weights, better measuring the actual effect of a country's sovereign spread relative to its economic importance. We compute the weights of sovereign debt securities for any country *(i)* using the following formula:

$$w_{\mathrm{j,i}} = \frac{v_{j.i}}{\sum_{j=1}^{n} v_{j.i}} \qquad (1)$$

where $v_{j.i}$ is the total currency value of a sovereign bond with a maturity *(j=1,2..n)* in a country (*i*), $\sum_{j=1}^{n} v_{j.i}$ is the sum of the total currency value of all *n* issues of sovereign bonds in country *(i)*, and $w_{\mathrm{j,i}}$ is the percentage (%) weight of a sovereign bond with a maturity *(j)* of the total currency value outstanding of all issues of sovereign bonds in a country *(i)*. Also, we compute the value-weighted theoretical yield for sovereign debt any given country (*i*) at time (*t*) using the following formula:

$$Y_{\mathrm{i},t} = \sum_{j=1}^{n} w_{j,i}\, \mathrm{y}_{i,\mathrm{j},t} \qquad (2)$$

where $y_{i,j,t}$ =is the yield at time (*t*) of any country (*i=1,…,43*) for bonds of maturity *(j)* . Notice that $w_{j,i}$ is kept constant[5] at all times (t) in the total issued amount outstanding of any given country (*i*). $Y_{i,t}$ is the proxy for the market-weighted theoretical yield for a country (*i*). Another distinctive advantage of zero coupon yields is that it is easy to compute the weighted average theoretical duration of currently traded issues. Therefore, the weighted average duration for a set of different maturity country yields is given by the following formula:

$$\mathrm{Dur}_i = \sum_{j=1}^{n} w_{j,i} dur_{j,i} \qquad (3)$$

where Dur_i is the weighted average country yield duration of country *(i)* in years and and $dur_{j,i}$ is the years to maturity *(j=1,2..n)* of a sovereign bond in a country (*i*). Finally the observed spread for any country *(i)* is given by the following formula:

$$spread_{i,t} = Y_{i,t} - Y_{us,t\approx \mathrm{Dur}_i} \qquad (4)$$

where $Y_{i,t}$ = is the proxy for the market weighted theoretical yield and $Y_{us,t\approx D_c}$ is the USD FMCZCB with closest maturity to the duration obtained in equation (3).

Using daily data for the FMCZCB from January 3, 2000 to May 31, 2013, we compute the monthly average yield for each country and calculate the theoretical market-weighted spread using equation (1) to (4) and aggregate them at the portfolio level for nine (9) groups: an 'all countries' portfolio which includes the 43 countries in the sample; 'developed and emerging

[5]In order to compute the weights we use the last reported total issued amount outstanding as of May 31st, 2013, since there is no longitudinal data source on amount issued just the snapshot at the collection time. This is a data limitation problem which in our opinion does not affect the result much since the most countries tend to rollover maturing debt with new issues with similar amounts.

countries' portfolios which are divided according to MSCI classification before the European Sovereign Debt (ESD) crisis in which Greece is considered a developed country and not an emerging market as the post ESD re classification; a 'Euro' portfolio which includes all countries from the Euro zone that issue their debt in Euros; a 'USD' portfolio which includes the countries that issue debt in USD dollars; a 'Local' portfolio which includes all those countries that issue their debt in local currency; and finally a 'Local developed and emerging' countries portfolio for sovereigns that issue debt in their home currency and the troubled countries or Portugal, Ireland, Italy, Greece and Spain (PIIGS) portfolios. Table 1 reports descriptive statistics for the portfolio spreads obtained from the sample. In order to aggregate the portfolios we apply equation (5):

$$SPREAD_{p,t} = \left(\frac{V_{i,p}}{\sum_{i=1}^{p} V_{i,p}} \right) spread_{i,\mathrm{p,t}} \qquad (5)$$

Where $spread_{i,\mathrm{p,t}}$ is the spread of equation (4) for a country *(i)* that is part of portfolio *(p)* at time *(t)*, $V_{i,p}$ = the total value outstanding of a member country *(i)* of portfolio *(p)* converted to USD dollars in case of issues in Euros or local currency using the exchange rate of May 31, 2013 for the same reasons explained in footnote 5, $\sum_{i=1}^{p} V_{i,p}$ = the sum of the total value of sovereign bonds outstanding for all the countries *(i)* that conform a specific portfolio *(p)*, and $SPREAD_{p,t}$ is the market value weighted spread of portfolio *(p)* at time *(t).*

(Insert Table 1 about here)

From the descriptive statistics we can observe that each of the portfolios has high kurtosis and skewness which reflects a large degree of heterogeneity in the sample. As expected, the PIIGS portfolio exhibits higher volatility in wake of the European Sovereign Debt crisis and the

local currency developed countries portfolio exhibits the lowest volatility. The reason that some portfolios exhibit negative spreads can be explained by the fact that some developed countries like the UK, Germany, and Japan had lower nominal rates than the US on average during the period under study.

Finally, our choice of explanatory variables for common factor or "shift contagion" includes the global and US equity premiums, the European Bond Index, a regional bond index as well as the global risk aversion index. The global equity premium and U.S. equity premiums are proxied by the S&P Global and S&P 500 indexes net of exchange rate variation and the risk free rate. In order to account for the effect of the regional bond prices, we use the approach employed by Longstaff et al., (2011) by including the returns to the regional bond portfolio excluding the country under observation. For the European bond index we use the EFFA, which is a Bloomberg market-weighted index that includes all the Eurozone government debt with a maturity longer than one year. Finally the Chicago volatility index (VIX) proxies for global risk aversion. All the data for common or "shift-contagion" proxies were extracted from Bloomberg. In the case of the explanatory variables for country specific determinants or "wake-up contagion", the local premium is represented by the changes of the local stock market of each country, adjusted by the domestic currency/USD exchange rate. We also deduct the risk free rate, here proxied by the US Treasury zero coupon yield of similar maturity to the constructed bond portfolio for each country. We also include a set of macroeconomic variables commonly used in other studies and that are explained in detail in Section B. All data for the country specific determinants were extracted from the IMF statistics module in Bloomberg in order to guarantee harmonization among the variables, except the growth rate of GDP per capita provided by the World Bank.

B. Factor model

To measure the effect of country specific determinants in sovereign spreads we begin with a panel data model. Martinez et al. (2013) argue that panel data models can deal with the cross sectional heterogeneity and time effects that are present in macroeconomic data. Baur and Fry (2009) argue that in a panel data model with common factors, significant time fixed effects capture the latent or pure contagion factor. Most of the studies[6] that attempt to explain the behaviour of spreads use macroeconomic variables as country specific factors; here we follow the specification proposed by Giordano, Pericoli, and Tommasino (2013) where:

$$spread_{i,t} = \alpha_o + \alpha_1 spread_{i,t-1} + \beta_{i,t} Z_{i,t} + \beta_{i,t} F_t + \gamma_o D_{c,t} + \gamma_1 Z_{i,t} D_{c,t} + \gamma_2 F_t D_{c,t} + \varepsilon_{i,t} \quad (6)$$

Where α_0 is the common intercept, $Z_{i,t}$ is a vector of country specific factors which in our model are the exchange rate, total debt to GDP ratio, investment to GDP ratio, external debt to exports ratio, GDP per capita growth, reserves, and the local equity premium[7]. F_t is a vector of common factors which in our model are the global equity premium, US equity premium, the regional bond portfolio and the global risk aversion[8] and the subscripts *i* and *t* stand for country and month respectively. The expected sign of the coefficients of both country specific ($Z_{i,t}$) and common (F_t) factors are summarized in Table 2:

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[6] Recent examples of studies that apply panel techniques for explaining sovereign spreads using country specific determinants can be found in Balazs and Ivaschenko (2013), Beirne and Fratzscher (2013), Aizenman et al. (2012), and Hilscher and Nosbusch (2010)

[7] The amount of literature about country specific proxies is beyond the scope of this paper, but some classic examples can be found in Eichengreen and Mody (1998), Boehmer and Megginson (1990), Edwards(1984), Edwards and Levy Yeyati (2005), Dittmar and Yuan (2008), and Berg et al. (2005) just to mention a few.

[8] Some examples of using the common factors and proxies of global risk aversion stock can be found in Coudert and Gex (2008), Longstaff et al. (2011), and Dahiya (1997).

(Insert Table 2 about here)

In order to test for a specific channel of transmission during a crisis period we look at the significance of the γ coefficients during the crisis periods ($D_{c,t}$) with the country specific and common factors. Additionally the latent factor is represented by ($\gamma_o D_{c,t}$), in this case a significant γ_o can be interpreted as "pure contagion" or a latent factor that is neither related to the change or level in country fundamentals or common factors, but possibly attributable to unobservable factors (G. Calvo, 1988; G. A. Calvo and Mendoza, 2000). A significant γ_1 can be interpreted as "wake-up contagion" or a change in country specific factors that leads investors to reassess their investment position in one country based on similarities of country factors fundamentals in crisis countries (Goldstein, 1998). Finally, a significant γ_2 can be interpreted as "shift contagion" or increases in the correlation of a global factor with a set of countries or region during a crisis period (Bekaert et al., 2011; Forbes and Rigobon, 2002).

Crisis indicator variables take the value of one in each of the three different phases of the GFC between 26th of July until the 17th of May 2012. We name and date the different crisis phases as follows: The first phase 'subprime' crisis (D_{Sub}) begins July 26th, 2007 which was the day the Dow Jones recorded a significant large loss in response to bad news from mortgage lender Country Wide Financial. At this point, the market processed news of "difficult conditions" in the subprime market following Country Wide Financial Corporation's SEC filing on the 24th of July. The beginning of the 'credit crunch' crisis (D_{Credit}) is generally dated from the time Lehman Brothers filed for bankruptcy on 15 September 2008. The European sovereign debt crisis (D_{ESD}) we date from 22 October 2009 when Fitch first downgraded and reported a negative outlook for Greek sovereign debt until the 17 of May 2012 where the same agency

upgraded it again from a default rating due to the compromise reached by the Greek government with the European monetary authorities[9].

Finally in order to deal with possible misspecification issues present in the base regression we use a two-step process to select the most relevant variables. In the first step we estimate a stepwise (backward and forward) panel OLS regression to eliminate those variables that are statistically insignificant for each of the nine (9) portfolios groups mentioned in subsection A. In the second step we estimate a second OLS regression with the obtained coefficients, but this time including country fixed effects or country heterogeneity and robust White heteroskedasticity consistent covariance matrix errors. The stepwise procedure in variable selection has been used by Carrieri, Errunza, and Hogan (2007) for selecting variables for market integration and the robust error specification has been used by Longstaff et al. (2011) for analysing CDS sovereign spreads. This procedure is repeated for each of the nine (9) portfolios for a total of 9 regressions. In table 3 we report the results obtained for the whole period of the GFC:

(Insert Table 3 about here)

In the case of the Eurozone and the PIIGS portfolios, the regional bond portfolio is the most relevant common factor in explaining spread variation. In addition, when we allow for changes in channels of transmission using crisis dummies, we find evidence of latent factor contagion in the Subprime and ESD crisis. In the case of wake-up contagion in the Eurozone and PIIGS, the most significant determinants are the investment to GDP ratio and the current account

[9] The key dates for the Subprime and credit crunch crisis were taken from the financial turmoil timeline chart from The Federal Reserve Bank of St Louis http://timeline.stlouisfed.org/pdf/CrisisTimeline.pdf and for the European sovereign debt crisis from the credit rating function in Bloomberg. There are other studies that use similar dates for the credit crisis and place the subprime around the same period, including Frank and Hesse (2009), Dooley and Hutchison (2009) and Felices and Wieladek. (2012).

deficit to GDP, which are liquidity related. Common factor contagion in both portfolios is explained by the European bond Index and US equity Premium (Eurozone) and just the European Bond Index in the case of the PIIGS. Beirne and Fratzscher (2013) reached a similar conclusion using data at the individual country level, but in our case we found no evidence that fundamental or "wake-up contagion" had a greater impact than common factor contagion at least at the aggregate level.

When we compare the common characteristics of the emerging and developed market portfolios, we observe that country specific factors such as the debt to GDP ratio and the exchange rate are more significant in emerging markets. In the case of common factors, the impact in spread variation is larger in developed countries. When we test for "wake up" contagion in the different phases of the crisis, both the developed and emerging market portfolio are sensitive to changes in fundamentals related to liquidity during the ESD phase (developed) and the credit phase (emerging). Giordano et al. (2013) argued that this increase in fundamentals significance in developed countries during the ESD was due to bad news originating from the PIIGS that led investors to closely monitor country specific liquidity proxies in other countries.

Finally, when we control for the currency denomination of debt (USD, Local, Local developed, and Local emerging) an interesting result is that the exchange rate is a significant common factor in the USD currency denominated portfolio but not in the other three. In the case of the local developed and local emerging currency portfolios the determinants behave similarly to the emerging and developed counterparts without adjusting for currency. However, an important difference is that in the case of the local developed currency portfolio, common factor contagion by multiple channels during all phases is the key source of spread variation. In the case of the local emerging currency portfolio there is "wake up" contagion during the credit

phase and common factor contagion during the ESD crisis. The global market premium as a common factor source of transmission is just relevant during the subprime phase. Similar to Balazs and Ivaschenko (2013) we found evidence that global risk aversion becomes a significant factor during the crisis, but in the case of the local developed and local emerging currency portfolio this significance seems to be more related to common factors rather than country-specific fundamentals or "wake up" contagion.

In the case of additional channels of transmission there is a "pure contagion" latent factor in most of the portfolios, but we hypothesize that the latent factors can be explained by a global bond portfolio that is not accounted for in the model, since we observe that once all countries are aggregated into one portfolio the latent factor contagion disappears. In the case of the USD and local developed portfolios the latent factor, albeit significant, exhibits a negative sign which can be evidence of "positive contagion" as defined by Baur and Fry (2009). Finally, the local equity premium is the most common significant characteristic across all portfolios with the exception of the Eurozone and PIIGS portfolios.

III. Proposed empirical method for testing differences in spreads during the GFC

At the next stage we use factors identified as significant from the estimation of equation (6) for each of the nine portfolios, and we can obtain the implied probability of being in a crisis period using the following logit form:

$$\Pr(D_{\mathrm{GFC},t} = 1 \,|\, X_{i,t}) = (1 + \exp(-\alpha_o - \beta_{i,t} X_{i,t} - \varepsilon_{i,t}))^{-1} \tag{7}$$

where $D_{\mathrm{GFC},t} =$ is an indicator function denoting the global financial crisis which encompasses all the three phases ; $X_{i,t}$ is a vector that contains all the significant country specific factors ($Z_{i,t}$) and common factors (F_t) identified in the two step procedure detailed in the previous section. Once we obtain the coefficients of interest and the predicted probabilities of the cumulative standard logistic distribution ($\Pr(\mathrm{D}_{\mathrm{GFC},t} = 1)$) from equation (7), we can compute the fitted cumulative probability that the observation is not in the crisis 'treatment':

$$p_{i,t} = 1 - \Pr(\mathrm{D}_{\mathrm{GFC},t} = 1 \mid X_{i,t}) \qquad (8)$$

Once we have estimated these probability values for all the countries at each point in time, we implement a matching procedure that we will describe in the following paragraphs. The results of the logit regression for the whole period of the GFCusing the significant coefficients obtained from the stepwise procedure in Table 3 are summarized in Table 4:

(Insert Table 4 about here)

Our procedure for testing differences in spreads is based on the Average Treatment Effect on the Treated (ATET) framework. This procedure uses the probabilities obtained in equation (8) and the original sovereign spread values to make a selection of counterfactual values based on propensity score matching. This procedure has certain advantages over traditional sampling or predicted values difference testing since it effectively addresses the problem of selection bias of comparable sample groups during the non-crisis period. One key advantage of this method is

that we can compare the actual value of the spreads without forgoing the theoretical richness contained in the observable characteristics of a pricing factor model. Finally with ATET it is possible to determine exactly which observations in the non crisis are more closely related in terms of common determinants to those in the crisis periods which can have important implications regarding policy making or early warning systems.

This method was originally developed by (Rosenbaum and Rubin, 1983) in order to address the non-randomness of treated vs. non-treated groups in medical trials, and since then has been applied to other areas of the social sciences such as labour economics and finance. In this paper, we modify the framework proposed by (Nssah, 2006) on how to apply ATET to economic policy programs and reframe it for contagion testing. In the context of corporate bond markets, this framework has been used to test the impact of credit supply shocks in the capital structure of the firm (Almeida et al., 2009).

Here, the "treated" group is characterized by a dummy that represents the crisis dates (D=1) and the "non-treated" which are represented by the non-crisis dates (D=0). Therefore, by dividing the spreads ($spreads_{i,t}$) from equation (3) into two vectors that represent the crisis period ($\{spreads_{crisis}\}$) and non-crisis period ($\{spread_{noncrisis}\}$) using the algorithm in equation (11) we have:

$$\{g_i\} = (\{spreads_{crisis}\} - \{spread_{noncrisis}\}) \tag{9}$$

where the average value of the vector $\{g_i\}$ is equal to the ATET. Additionally, if we assume that there is unit homogeneity[10], since in a global crisis countries do not have the freedom to "choose" whether to participate or not in it, we can rewrite $\{g_i\}$ in conditional probability form where:

$$ATET = E\left(\{g_i\}\middle|X, D=1\right) = E\left(\{spreads_{crisis}\}\middle|X, D=1\right) - E\left(\{spreads_{noncrisis}\}\middle|X, D=0\right) \quad (10)$$

Where X is the vector of common observable characteristics represented by the explanatory variables from equation (4) and the averages of $E\left(\{\Delta\% y_1\}\middle|X, D=1\right)$ and $E\left(\{\Delta\% y_0\}\middle|X, D=0\right)$ represent respectively the mean of the "treated" and the counterfactual mean of the "non-treated" or, in our setup, the crisis and non-crisis period. ATET using propensity matching estimators represents an interesting framework for testing contagion because the method yields strong estimates under the assumption of conditional independence (Abadie et al., 2004). The assumption can be formally defined as:

$$\left(spreads_{crisis}, spreads_{noncrisis}\right) \perp D\middle|X\right) \quad (11)$$

In other words, conditional on observable characteristics (X), participation (D) is independent of the potential outcomes of $\left(spreads_{crisis}, spreads_{noncrisis}\right)$. In order to be coherent with the principle of conditional independence, the basic idea behind propensity matching is to randomly select a

[10] Unit homogeneity refers to the fact that participants cannot choose to participate in the experiment, so the experimental group is comprised of both volunteer and non-volunteers; there is no bias based on the willingness of the participants to be a part of a given experiment.

sample from the non-crisis (non-treated) period that most closely resembles the characteristics of our sample in the crisis (treated) period. In other words, conditional on the common factors , the counterfactual observations of the non-crisis period will be the one that more closely resembles in terms of conditional variance those observations during the crisis period. Since the counterfactual group is selected randomly based on the closest characteristics with a treated observation, any source of endogeneity due to selection bias is effectively addressed.

Using the probability values from equation (8) we can implement the algorithm in equation (12) for finding the vector with nearest neighbour matching estimators (NNB):

$$c(p_{\text{matched},t}) = \left\{ j \left| \min \left\| p_{\text{crisis},t} - p_{\text{noncrisis},t} \right\| \right. \right\} \tag{12}$$

Where $c(p_{\text{matched},t})$ represents the vector of matched crisis and non-crisis spreads based on the nearest difference propensity scores which are simply the one minus the cumulative probabilities obtained using equation (7), where (p_{crisis}) are the cumulative probabilities for those observations in the crisis period and ($p_{\text{noncrisis}}$) are those of the non-crisis period. The vector that represents the non-crisis period ($\{ spread_{noncrisis} \}$) is constructed by selecting the spreads that match the corresponding dates of the $p_{\text{noncrisis}}$ cumulative probabilities obtained with equation (10). Therefore, we can find evidence if there is difference in spreads by testing if the average of the matched vector $\{g_i\}$ is statistically significant via a simple ANOVA test where the null of no differences in spreads versus the alternative is formally defined as:

$$H_0 : \overline{spreads}_{crisis} = \overline{spreads}_{noncrisis}$$
$$H_1 : \overline{spreads}_{crisis} \neq \overline{spreads}_{noncrisis} \quad (13)$$

In this hypothesis, $\overline{spreads}_{crisis}$ and $\overline{spreads}_{noncrisis}$ are the mean values of the observations in vectors $\{spreads_{crisis}\}$ and $\{spreads_{noncrisis}\}$ according to the matched propensity scores in vector $c(p_{\text{matched},t})$. In this way we observe the impact of the spreads in the crisis periods relative to the observations that most closely resemble the crisis characteristics in the noncrisis periods as well as overlapping periods. Furthermore, we observe the effect of changing averages in spreads during three different phases of the GFC (Subprime, Credit, and ESD) as well as for the whole period of the GFC between 26th of July until the 17th of May 2012. We compare these results with the ones obtained by using other criteria of equal and unequal samples of the noncrisis period as is often the case for other contagion testing methodologies that use correlations or test for increases in factor loadings (Dungey et al., 2005).

IV. Results

Table 5 Panel A. reports the results obtained from the matching procedure using country specific determinants. In the case of the total period (GFC) all counterfactuals are drawn solely from the non crisis period.. In the case of the crisis phases we allow for counterfactuals from the non crisis periods and other phases in order to see if there are significant differences among crisis periods. Our results show that for our portfolios there was a significant difference in spreads for the whole period of the GFC with the exception of local currency issued emerging market debt in which the difference with comparable counterfactuals in the past is statistically insignificant. The

significant changes in spreads in most groups can be explained by cross market linkages through fundamentals related to liquidity or "wake up contagion".

Although the case of local currency emerging debt could be viewed as counterintuitive because this kind of debt has been traditionally considered to be a high risk investment, it is important to recall that we are comparing the *characteristics* of a certain crisis period with the *characteristics* of a different period that *most closely* resembles those of the crisis period in the past. In the case of local currency emerging market debt this means that there were periods with *similar severity in terms of variance* which do not necessarily translate to *low* or *high magnitude* in the changes of spreads. The average spread in the GFC for the local currency emerging market debt issuers was 335.01 basis points and those selected in the noncrisis period using neighbour matching estimators (NNB) was 316.46.

(Insert Table 5 about here)

In the case of the GFC (see Table 5 Panel A) the most significant statistical difference in spreads was from the troubled countries (PIIGS) and those countries that issue US dollar denominated debt. In the case of the PIIGS the channel of contagion was related mainly to leading macroeconomic indicators of liquidity (current account and investment to GDP) and changes in the sovereign spreads in the other troubled countries that are part of the PIIGS portfolio. On the other hand, the US dollar denominated debt change in spreads is attributable to cross market linkages among fundamentals related to liquidity and evidence of a latent factor with a "positive contagion" effect. In the case of the subprime phase the change in spreads was statistically significant in developed and Eurozone countries. In the case of the USD dollar denominated debt portfolio we observe a significant reduction of spreads of -64.27 basis points.

One reason could be investors replacing US backed mortgage securities with other USD dollar denominated debt.

In the credit crisis period the change in spreads was statistically significant in emerging countries, and especially US dollar denominated debt issues, probably because liquidity in the US market dried up after the Lehman collapse. We observe an average increase in the cost of USD debt issues of 279.02 basis points. Curiously, the PIIGS and the Eurozone portfolio reported a reduction of -141.74 and -39.66 basis points respectively during that phase. This reduction could be attributable to rebalancing effects by investors from the US to the Eurozone amid the drain of liquidity in the US markets. Finally, we can observe that in the ESD phase all the portfolios reported significant changes, with the exception of the USD and local currency debt issues in developed countries. As expected, the PIIGS portfolio reported the biggest increase in spreads with a total of 191.94 basis points during the ESD phase.

The results reported in table 5 Panel A using the ATET framework are strikingly different with those reported in Panel B and Panel C in which we allow for equal and unequal samples in all the phases using standard exogenous dating methods. The only exception is the US dollar debt denominated portfolio that does not report significant statistical changes during the subprime phase. Even when we allow for overlapping samples, the results are grossly underestimated or overestimated when compared with results obtained with matching estimators. The most compelling argument for the use of matching estimators is that we can have a reliable measure of the economic impact in the spreads that effectively incorporates the information of the determinants in the reported change. Therefore, in Table 6 we show the results of robustness checks using alternative matching kernels that impose a region of common support which means that we limit our draws of counterfactuals to those observations that are between the minimum

and maximum probabilities of the crisis period values, as outlined in Appendix A. This alternative kernels further refines the sample universe by setting minimums and maximums

(Insert Table 6 about here)

Where two of the three methods yield similar results, we categorize the result as being a meaningful difference, otherwise we keep the original results. From the robust specification, we can observe that in the case of local currency emerging market debt issuers the difference in spreads is statistically insignificant and in the order of 0.93 basis point during the subprime crisis as opposed to 5.32 basis points using the previous method. In the Subprime and Credit phase there is evidence of a significant increase in the spread difference for the all countries portfolio using the robust method. The results concerning the behaviour of local currency emerging market debt are in line with other studies that suggested the possible decoupling of emerging markets during the early phases of the GFC (Dooley and Hutchison, 2009) and to a more recent study by Dungey et al. (2010) which found that the U.S. subprime crisis had only a small impact in the volatility of emerging sovereign bond market albeit both studies employed totally different methodologies.

V. Conclusions

By using a factor model based on country specific and common market determinants of sovereign spreads in the context of propensity matching estimators we propose a novel framework to test for differences in spreads. Our findings suggest that the most common country specific factor among portfolios groups is the local equity premium with the exception of the Eurozone and PIIGS where the changes in neighbouring countries (regional portfolio) have a larger effect. However, in the specific case of the global financial crisis there were different channels for transmission of contagion. The most common channel of contagion transmission

among most portfolio groups were macroeconomic fundamentals related to liquidity or "wake up contagion" where investors pay close attention to the country's ability to meet their financial obligations. There was evidence of a latent factors or "pure contagion" in all of the portfolios with the exception of the all countries portfolio, suggesting that most of the latent factors in the remaining portfolios can be explained by changes in the global bond portfolio. The channel of contagion in the case of local currency issuers during all the phases were related to common factor contagion (global equity premium, the European Bond Index, regional portfolio and changes in the perception of global risk aversion).

Additionally, in our proposed framework, we define our test for differences in spreads as a statistically significant change in the average change in spreads between the observations in the counterfactual noncrisis period and those of the crisis period. We do this in order to determine the actual economic significance in basis points of the different phases of the crisis versus non crisis periods. In order to do this we define this average change as our average treatment effect on the treated (ATET), where the 'treatment' is the crisis period. In this way, we are able to obtain estimates based on a similar distribution between the crisis and counterfactual group and reduce the problem of selection bias inherent in ANOVA testing . We test the robustness of the results using equal, unequal and overlapping non crisis periods and also using different kernel specification of matching estimators without significant changes in our main results.

In summary, the evidence shows that the most meaningful periods for differences in sovereign spreads was the ESD phase in which the spreads rose substantially from the previous crisis periods. The exception was the US dollar debt denominated portfolio which displayed a major variation in spread during the credit crisis phase. The portfolios that were most affected in terms of spreads during the GFC were the troubled countries (PIIGS) and the US dollar debt

denominated portfolio. For the market weighted portfolio of the 43 countries in our sample the average spread rose by 70.78 basis points compared with similar events during the noncrisis period. Finally, we found evidence that the portfolio of local currency emerging market debt did not exhibit any significant difference in spreads during the GFC as a whole, even under robust specifications. This means that based on the common characteristics of the counterfactuals, the emerging countries that issued debt in local currency have dealt with similar economic conditions in the past.

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Appendix A-Robustness checks

In order to check the robustness of our results, we use two other algorithms based on kernel matching. The difference between neighbour matching and kernel algorithms is that the first assign equal weights to all matched observations drawn from the non-crisis period and the later give more weight to the observations that are more closely matched. Following the implementation procedure used by Nssah (2006), the proportional weight assigned to the observations in the non-crisis period (p_j) as a function of how close they are to the crisis period (p_i) is:

$$w_{ij} = \frac{K\left(\frac{p_i - p_j}{h}\right)}{\sum_{j \in \{d=0\}} K\left(\frac{p_i - p_j}{h}\right)} \quad , \qquad (14)$$

where w_{ij} is the assigned weight, and h is the bandwidth which is set at a fixed value of 0.06 (Becker and Ichino, 2002). We define K as the Gaussian (GAUSS) and Epanechnikov kernel (EPNK):

$$K(u) = \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-u^2}{2}\right)$$
$$K(u) = \frac{3}{4}(1-u^2)\, \mathrm{xI}(|u| \le 1) \qquad (15)$$

where u=(p_i- p_j)/h and I is an indicator variable that takes the value of 1 (true) and 0 (false) when the condition $\|p_i - p_j\| < 0.06$ is met. For these two kernels, we also establish an area of common support based on the minimum and maximum propensity scores in the crisis period obtained from equation (6). This limits the sample observations drawn from the non-crisis

period to those values within the range of those in the crisis period, further reducing the possibility of biases due to outliers.

Table 1-Descriptive statistics sovereign spreads (monthly)

This table reports the descriptive statistics of the market-weighted spreads over the US zero coupon yield of the same maturity (equation 5) as reported by Bloomberg (FMCZCB) from January 1, 2000 to May 31, 2013 for the 43 countries in our sample. The results are reported in basis points on a monthly basis. A negative spread sign implies that the spread in that protfolio was lower in average than that in the US during the period of observation. The spreads are aggregated into nine (9) market weighted portfolios. The countries that comprise each portfolio are below their respective column.

All Countries		**Developed**	**Emerging**	**EUR**	**USD**	**LOCAL**	**Local Developed**	**Local Emerging**	**PIIGS**
Mean	110.51	-9.37	273.42	23.66	351.78	76.62	-22.30	224.70	95.93
Median	37.75	-38.53	222.57	-36.50	247.46	36.62	-35.90	227.41	-22.24
Maximum	4147.66	4147.66	2129.80	4147.66	2129.80	1010.10	1519.81	1010.10	4147.66
Minimum	-569.53	-569.53	-369.39	-265.31	0.00	-569.53	-569.53	-369.39	-265.31
Std. Dev.	287.78	236.71	270.48	285.55	308.29	232.80	195.26	226.69	417.91
Skewness	2.85	6.70	1.48	7.26	1.78	0.53	1.77	0.34	4.98
Kurtosis	25.41	91.26	7.74	80.82	7.58	3.32	13.66	2.77	38.21
Observations	6407	3691	2716	1881	1151	3375	2093	1443	793
Colombia	Japan	Austria	Colombia	Austria	Colombia	Chile	Australia	Chile	Portugal
Brazil	Malasya	Australia	Brazil	Belgium	Brazil	Peru	Canada	Peru	Italy
Mexico	Netherlands	Belgium	Mexico	Finland	Mexico	Australia	Denmark	Bulgaria	Ireland
Venezuela	New Zealand	Canada	Venezuela	France	Venezuela	Bulgaria	Hong Kong	Czech Republic	Greece
Chile	Norway	Denmark	Chile	Germany	Indonesia	Canada	Japan	Hungary	Spain
Peru	Philippines	Finland	Peru	Greece	Philippines	Czech Republic	New Zealand	India	
Austria	Poland	France	Bulgaria	Ireland	Russia	Denmark	Norway	Malasya	
Australia	Portugal	Germany	Czech Republic	Italy	Slovakia	Hong Kong	Singapore	Poland	
Belgium	Romania	Greece	Hungary	Netherlands	Turkey	Hungary	Korea	Romania	
Bulgaria	Russia	Hong Kong	India	Portugal		India	Sweden	South Africa	
Canada	Singapore	Ireland	Indonesia	Slovakia		Japan	Switzerland	Thailand	
Czech Republic	Slovakia	Italy	Malasya	Singapore		Malasya	United Kingdom		
Denmark	South Africa	Japan	Philippines	Spain		New Zealand			
Finland	Korea	Netherlands	Poland			Norway			
France	Spain	New Zealand	Romania			Poland			
Germany	Sweden	Norway	Russia			Romania			
Greece	Switzerland	Portugal	Slovakia			Singapore			
Hong Kong	Thailand	Singapore	South Africa			South Africa			
Hungary	Turkey	Korea	Thailand			Korea			
India	United Kingdom	Spain	Turkey			Sweden			
Indonesia		Sweden				Switzerland			
Ireland		Switzerland				Thailand			
Italy		United Kingdom				United Kingdom			

Table 2-Determinants and their relation with sovereign spreads

Country specific factors	*Common factors*
1) The exchange rate is expected to have a positive (+) coefficient since depreciations are associated with weaker economic conditions and higher spreads.	1) The global market equity premium acts as a transmission mechanism of global conditions and is expected to have a negative (-) coefficient if there is a strong global outlook, under weak global prospects is expected to have a (+) sign.
2) The ratio of debt to GDP (Debt/GDP) is expected to have a positive (+) coefficient. An increase in this ratio implies an increase in the probability of default. Consequently, the creditors would require a higher spread in order to compensate for this additional risk.	2) The European Bond index acts as a plausible transmission mechanism of global conditions during the European Sovereign Crisis and can either have a negative (-) or positive (+) coefficient depending on the region of analysis.
3) The ratio of investment to GDP (Investment/GDP) whether the sign is positive (+) or negative (-) is still an ongoing debate. A higher investment ratio can be tied with future GDP growth and better economic perspectives, so if this is the case the sign of the coefficient is expected to be negative. However, a higher investment ratio can also be financed by increasing public debt and if this is the case, the coefficient is expected to have a positive sign.	3) The US equity premium acts as a plausible transmission mechanism of global conditions during the Subprime and Lheman Brothers crisis episodes and can either have a negative (-) or positive (+) coefficient depending on the region of analysis.
4) The ratio of debt to exports (Debt/Exports) acts as a proxy for debt service and liquidity. A higher ratio is related with lower liquidity and a greater strain on available resources to meet future debt servicing obligations, so for this variable we expect a positive (+) sign.	4) The regional bond portfolio acts as a plausible transmission mechanism of regional conditions during all crisis episodes and can either have a negative (-) or positive (+) coefficient depending on the region of analysis.
5) GDP per capita is expected to be negatively (-) correlated with spreads. A positive increase in GDP per capita can be interpreted as a proxy for country development and enhanced terms of credit due to future expectations of GDP growth.	5) The global risk aversion index acts as the proxy for aggregate risk aversion during all crisis episodes and is expected to have a (+) sign during crisis periods as more risk adverse investors demand a higher spread.
6) The ratio of current account to GDP (Current Account/GDP) acts as a proxy for liquidity. A negative ratio represents a deficit and less liquidity to meet future obligations, so in this case we expect a negative (-) sign. A positive ratio represents a surplus more liquidity to meet future obligations, so in this case we expect a positive (+) sign.	
7) Reserves to GDP ratio (Reserves) are inversely correlated with spreads so for higher reserves we expect a negative (-) sign. The higher the foreign currency reserve the more likely is the country to meets its obligations. Imports behave exactly in the opposite way.	
8) The local equity premium is expected to have a negative (-) coefficient. An increase in the local stock market is related with the perception of strong economic growth.	

Table 3-Panel regression estimates

This table report the results of the panel regression: $spread_{i,t} = \alpha_o + \alpha_1 spread_{i,t-1} + \beta_{i,t} Z_{i,t} + \beta_{i,t} F_t + \gamma_o D_{\text{GFC},t} + \gamma_1 Z_{i,t} D_{\text{GFC},t} + \gamma_2 F_t D_{\text{GFC},t} + \varepsilon_{i,t}$ where $spread_{i,t}$ is the spread of any country *i* at time *t* from January 2000 to May 2013, α_0 is the common intercept, $Z_{i,t}$ is a set of country specific factors which in our model are the exchange rate, total debt to GDP ratio, investment to GDP ratio, external debt to exports ratio, GDP per capita growth, current account to GDP, imports, reserves, and local equity premium. F_t is a set of common factors which in our model are the global equity premium, US equity premium, the regional bond portfolio and the global risk aversion and the subscripts $_i$ and $_t$ stand for country and month respectively. D_{Sub} represents the dummy for the months of the 'subprime' phase of the GFC form July 2007 until August 2008. D_{Credit} represents the dummy for the months of the 'credit crunch' crisis form September 2008 until September 2009. D_{ESD} represents the dummy for the months of the European Sovereign Debt from October 2009 until May 2012. γ_0 represents "pure contagion", γ_1 represents "wake up contagion" and γ_2 represents the "common-factor contagion". ***1%; **5%; and *10% significance. In order to deal with endogeneity and possible misspecification issues present in the base regression we run a two-step process to select the most relevant variables. In the first step we run a stepwise panel OLS regression with backward and forward inclusion to drop those variables that are statistically insignificant for each of the nine (9) portfolios groups mentioned in subsection A. In the second step we run a second OLS regression with the remaining variables, but adjusting for cross sectional effects and robust White heteroskedasticity consistent covariance matrix errors.

	All Countries	**Developed**	**Emerging**	**EUR**	**USD**	**LOCAL**	**Local Developed**	**Local Emerging**	**PIIGS**
Spread (t-1)	0.9618***	0.9572***	0.9617***	0.9455***	0.9586***	0.9534***	0.9662***	0.9472***	0.9397***
	(0.0293)	(0.0556)	(0.0127)	(0.0561)	(0.0188)	(0.0071)	(0.0161)	(0.0100)	(0.0523)
Country specific factors									
Exchange Rate	0.0134***		0.0195***		0.0206**	0.0033		0.0094	
	(0.0042)		(0.0058)		(0.0084)	(0.0024)		(0.0061)	
Debt/GDP	-0.0007	-0.0011					-0.0007		
	(0.0012)	(0.0029)					(0.0006)		
Investment/GDP									
Debt/Exports	0.0010		0.0013**		0.0018**		-0.0006		
	(0.0008)		(0.0005)		(0.0007)		(0.0005)		
GDP per capita growth	0.0007	0.0027		0.0115		0.0032	0.0046**	0.0040	
	(0.0028)	(0.0040)		(0.0091)		(0.0021)	(0.0021)	(0.0029)	
Current Account/GDP									

Reserves						-0.0001		-0.0020	
						(0.0003)		(0.0014)	
Local Equity premium	-0.0155***	-0.0028*	-0.0132***		-0.0162***	-0.0158***	-0.0153**	-0.0091***	
	(0.0036)	(0.0016)	(0.0025)		(0.0041)	(0.0050)	(0.0061)	(0.0023)	
Common factors									
Global Equity premium	-0.0069*					-0.0098*	-0.0131**		
	(0.0035)					(0.0052)	(0.0062)		
European Bond Index	0.0436***	-0.0951***	0.0430***		0.0265*	0.0549***		0.0582***	
	(0.0115)	(0.0299)	(0.0125)		(0.0147)	(0.0103)		(0.0115)	
US Equity premium			-0.0142**		-0.0249**	0.0065	0.0127**		
			(0.0070)		(0.0112)	(0.0056)	(0.0064)		
Regional Bond Portfolio	-0.1405	1.1907***		0.3234***		-0.1089	0.3935***		0.4395***
	(0.1090)	(0.2935)		(0.1106)		(0.0917)	(0.1040)		(0.1490)
Global Risk Aversion	-0.0021**		-0.0023*		-0.0032*	-0.0012			
	(0.0009)		(0.0012)		(0.0017)	(0.0007)			
	All Countries	**Developed**	**Emerging**	**EUR**	**USD**	**LOCAL**	**Local Developed**	**Local Emerging**	**PIIGS**
Pure contagion									
Dummy Subprime (D_{Sub})	0.0622	0.0704	0.0230	0.1131**	-0.1721*	0.1020***	0.0478*	0.1447***	0.1384***
	(0.0432)	(0.0554)	(0.0792)	(0.0476)	(0.1024)	(0.0321)	(0.0251)	(0.0441)	(0.0432)
Dummy Credit (D_{Credit})	-0.0875	-0.1126*	0.0030	-0.0063	-3.0413***	-0.0972	-0.1026***	0.1363	-0.0090
	(0.0693)	(0.0589)	(0.0986)	(0.0719)	(0.4359)	(0.0591)	(0.0316)	(0.3443)	(0.0857)
Dummy ESD (D_{ESD})	0.0083	0.3985***	0.0628*	1.2750***	-0.0602	0.0945***	0.0250	0.1763*	5.4985
	(0.0674)	(0.1542)	(0.0356)	(0.3609)	(0.0533)	(0.0262)	(0.0371)	(0.0912)	(3.8775)

	All Countries	Developed	Emerging	EUR	USD	LOCAL	Local Developed	Local Emerging	PIIGS
Wake-up contagion									
Exchange Rate x D_{Sub}	-0.0129**		-0.0240**			-0.0120*		-0.0252*	
	(0.0052)		(0.0108)			(0.0068)		(0.0131)	
Exchange Rate x D_{Credit}	0.0069			0.0213					
	(0.0100)			(0.0168)					
Exchange Rate x D_{ESD}	-0.0187***		-0.0288***		-0.0351***			-0.0165*	-0.0767
	(0.0059)		(0.0069)		(0.0092)			(0.0094)	(0.0623)
Debt/GDP x D_{Sub}									
Debt/GDP x D_{Credit}			-0.0040			0.0032			
			(0.0033)			(0.0021)			
Debt/GDP x D_{ESD}	0.0018*						0.0044***		
	(0.0010)						(0.0013)		
Investment/GDP x D_{Sub}									
Investment/GDP x D_{Credit}					0.1071***			-0.0213	
					(0.0120)			(0.0179)	
Investment/GDP x D_{ESD}		-0.0143**		-0.0526***				-0.0060*	-0.1694*
		(0.0069)		(0.0171)				(0.0035)	(0.0884)
Debt/Exports x D_{Sub}									
Debt/Exports x D_{Credit}			0.0025		0.0056**	-0.0029*		0.0046	
			(0.0031)		(0.0028)	(0.0017)		(0.0040)	
Debt/Exports x D_{ESD}		0.0013					-0.0043***	0.0030**	-0.0081
		(0.0012)					(0.0015)	(0.0013)	(0.0079)
GDP per Capita Growth x D_{Sub}	0.0035		0.0074		0.0159**				
	(0.0039)		(0.0059)		(0.0077)				
GDP per Capita Growth x D_{Credit}	0.0075				-0.0344**				
	(0.0114)				(0.0156)				

	All Countries	Developed	Emerging	EUR	USD	LOCAL	Local Developed	Local Emerging	PIIGS
GDP per Capita Growth x D_{ESD}									0.0649
									(0.0543)
Current Account/GDP x D_{Sub}									
Current Account/GDP x D_{Credit}			-0.0083**			-0.0062		-0.0095*	
			(0.0036)			(0.0039)		(0.0050)	
Current Account/GDP x D_{ESD}	-0.0092**	-0.0208***		-0.0529***			-0.0154***		-0.1720**
	(0.0037)	(0.0055)		(0.0116)			(0.0045)		(0.0854)
Reserves x D_{Sub}									
Reserves x D_{Credit}			0.0071**		0.0530***				
			(0.0031)		(0.0189)				
Reserves x D_{ESD}		0.0041***						0.0027***	
		(0.0016)						(0.0010)	
Imports/GDP x D_{Sub}									
Imports/GDP x D_{Credit}			-0.0399					0.0956***	
			(0.0323)					(0.0357)	
Imports/GDP x D_{ESD}		-0.0066*							-0.9423
		(0.0035)							(0.9688)
Local Equity premium x D_{Sub}							0.0354**	-0.0217***	
							(0.0146)	(0.0075)	
Local Equity premium x D_{Credit}	0.0168***		0.0100*		0.0302***	0.0244***	0.0357***		
	(0.0059)		(0.0057)		(0.0098)	(0.0050)	(0.0059)		
Local Equity premium x D_{ESD}	-0.0073		-0.0170**		-0.0652**		0.0280	-0.0354***	0.1862
	(0.0075)		(0.0083)		(0.0269)		(0.0199)	(0.0114)	(0.1470)

	All Countries	Developed	Emerging	EUR	USD	LOCAL	Local Developed	Local Emerging	PIIGS
Common-factor contagion									
Global Equity premium x D_{Sub}						0.0044	0.0403**	-0.0203***	
						(0.0032)	(0.0164)	(0.0078)	
Global Equity premium x D_{Credit}	0.0174***					0.0312***	0.0354***		
	(0.0059)					(0.0046)	(0.0061)		
Global Equity premium x D_{ESD}		0.0176	-0.0173*	0.0242	-0.0690**		0.0345*	-0.0340***	0.2115
		(0.0146)	(0.0093)	(0.0233)	(0.0288)		(0.0197)	(0.0120)	(0.1579)
European Bond Index x D_{Sub}						-0.0331	-0.1892***	-0.0620**	
						(0.0205)	(0.0167)	(0.0280)	
European Bond Index x D_{Credit}							-0.0855***		
							(0.0302)		
European Bond Index x D_{ESD}	-0.0536***	-0.0454	-0.0432**	-0.1820**		-0.0405***	-0.0334**	-0.0603***	-0.5840**
	(0.0202)	(0.0288)	(0.0177)	(0.0880)		(0.0131)	(0.0133)	(0.0169)	(0.2481)
US Equity premium x D_{Sub}							-0.0398**		
							(0.0167)		
US Equity premium x D_{Credit}		0.0302***			-0.0460			0.0328***	
		(0.0079)			(0.0322)			(0.0079)	
US Equity premium x D_{ESD}	-0.0123	-0.0311*		-0.0553*	0.0630*	-0.0131*	-0.0408*		-0.1819
	(0.0091)	(0.0176)		(0.0308)	(0.0325)	(0.0069)	(0.0210)		(0.1508)
Regional Bond Index x D_{Sub}							1.7600***		
							(0.4517)		
Regional Bond Index x D_{Credit}	0.4304***	0.8249***	0.6604***		0.5272*	0.3435***	1.5923***	0.2269	
	(0.1604)	(0.1900)	(0.2188)		(0.3143)	(0.1075)	(0.3140)	(0.1501)	
Regional Bond Index x D_{ESD}				0.9210					5.0835
				(0.9070)					(3.2470)
Global Risk Aversion x D_{Sub}	0.0020					0.0034*			
	(0.0017)					(0.0018)			

	All Countries	**Developed**	**Emerging**	**EUR**	**USD**	**LOCAL**	**Local Developed**	**Local Emerging**	**PIIGS**
Global Risk Aversion x D_{Credit}	0.0062***		0.0117**		0.0130	0.0052**	0.0040**	0.0047***	
	(0.0023)		(0.0056)		(0.0097)	(0.0020)	(0.0017)	(0.0017)	
Global Risk Aversion x D_{ESD}		-0.0033		-0.0073				-0.0037*	
		(0.0035)		(0.0068)				(0.0021)	
Adjusted R^2	0.9742	0.9637	0.9719	0.9552	0.9671	0.9886	0.9874	0.9803	0.9537
Number of observations	6325	3646	2679	1869	1126	3330	2058	1432	788

Table 4-Logistic regression estimates for calculating propensity scores

This table reports the results from panel logit regressions of the global financial crisis indicator variable on a set of the significant explanatory variables obtained in the two step procedure detailed in Table 3 and Section II.B. The regression equation is $\Pr(D_{GFC,t}=1|X_{i,t}) = (1+\exp(-\alpha_o - \beta_{i,t}X_{i,t} - \varepsilon_{i,t}))^{-1}$ where $D_{GFC,t}$ = The crisis indicator for the global financial crisis ($D_{GFC,t}$), it takes the value of 1 for the period between July 2007 until May 2012 and 0 otherwise. ***1%; **5%; and *10% significance. The propensity scores are obtained by calculating the predicted values of the regression using equation (8).

Dependent variable $D_{GFC,t}$	**All Countries**	**Developed**	**Emerging**	**EUR**	**USD**	**LOCAL**	**Local Developed**	**Local Emerging**	**PIIGS**
Spread (t-1)	0.2216***	0.3595***	0.1140***	0.2651***	0.0279	0.3146***	0.3991***	0.3515***	0.0138
	(0.0129)	(0.0282)	(0.0171)	(0.0403)	(0.0223)	(0.0196)	(0.0369)	(0.0319)	(0.0367)
Country specific factors									
Exchange Rate	-0.0174**		-0.0088		-0.0244	-0.0233*		0.0114	-0.0216
	(0.0080)		(0.0110)		(0.0156)	(0.0127)		(0.0175)	(0.0414)
Debt/GDP	-0.0067***	0.0013					0.0147***		
	(0.0012)	(0.0018)					(0.0024)		
Investment/GDP		0.0353***							
		(0.0030)							
Imports/GDP		-0.0021							
		(0.0068)							
Debt/Exports	0.0024**	-0.0003	-0.0046***		0.0011		-0.0110***		
	(0.0010)	(0.0016)	(0.0012)		(0.0014)		(0.0023)		
GDP per capita growth	-0.0949***	-0.1651***		-0.1904***		-0.1130***	-0.1074***	-0.0841***	-0.3719***
	(0.0057)	(0.0120)		(0.0171)		(0.0094)	(0.0140)	(0.0137)	(0.0382)
Current Account/GDP			-0.0074						-0.2245***
			(0.0068)						(0.0247)
Reserves		0.0132***				0.0181***		0.0512***	
		(0.0024)				(0.0016)		(0.0052)	
Local Equity premium	-0.0806***	-0.0433***	-0.0343***		-0.0332***	-0.2134***	-0.2013***	-0.0347***	-0.0655
	(0.0080)	(0.0070)	(0.0068)		(0.0096)	(0.0243)	(0.0295)	(0.0091)	(0.0689)

	All Countries	Developed	Emerging	EUR	USD	LOCAL	Local Developed	Local Emerging	PIIGS
Common factors									
Global Equity premium	-0.0442***					-0.1895***	-0.1712***		0.0554
	(0.0093)					(0.0257)	(0.0312)		(0.0787)
European Bond Index	-0.0828***	-0.6796***	-0.0441		-0.0431	-0.0832**		-0.0424	-0.7602***
	(0.0276)	(0.0809)	(0.0281)		(0.0431)	(0.0384)		(0.0399)	(0.2014)
US Equity premium			-0.0091		-0.0212	0.1585***	0.1722***		0.0158
			(0.0139)		(0.0213)	(0.0263)	(0.0328)		(0.0709)
Regional Bond Portfolio	0.2365	6.6870***		0.8082**		0.3729	0.3643		8.5107***
	(0.2400)	(0.8151)		(0.3677)		(0.3269)	(0.3578)		(2.1493)
Global Risk Aversion	-0.0068***		-0.0006	0.0068**	-0.0016	-0.0046			
	(0.0021)		(0.0031)	(0.0030)	(0.0047)	(0.0030)			
Pseudo R2	0.0829	0.1439	0.0262	0.1338	0.0143	0.1137	0.1069	0.1145	0.3785
Number of observations	6235	3646	2679	1869	1126	3330	2058	1432	788
Obs with Dependant=0	3818	2289	1529	1161	654	2003	1291	803	493
Obs with Dependant=1	2417	1357	1150	708	472	1327	767	629	295

Table 5- Average effect on sovereign spreads on portfolios

Panel A reports the results from matching the inverse cumulative probabilities (propensity scores) which are obtained by applying equation (8) to the predicted probabilities obtained from the logit regressions for each of the (9) portfolios during the whole GFC period. For the matching procedure between crisis and non-crisis periods we use the algorithm for the nearest neighbour matching estimator (NNB) in equation (12). The results reported in the NNB column correspond to the average monthly spread of the counterfactual vector obtained using equation (12). The Subprime, Credit and ESD columns correspond to the average monthly spread for each country during the different crisis dates outlined in Section II.B. The average treatment effect on the treated (ATET) is simply the arithmetic difference between a crisis period average and their corresponding NNB average. The statistical significance of the ATET is tested using an ANOVA test for equality of means of the vector containing the observations of a crisis periods and their respective vector of NNB counterfactuals. Panel B reports the results for the statistical difference in the average spreads using an unequal sample for the noncrisis period, which is dated from January 2000 to June 2007, versus the average spread for each portfolio in the respective crisis period. Panel C tests reports the results for the statistical difference in the average spreads using an equal sample for the noncrisis period versus the average spread for each portfolio in the respective crisis period, so in the case of the case of the whole GFC the crisis periods is 59 months the noncrisis period is exactly 59 months from August 2002 to June 2008. Panel D reports the results for the statistical difference in the average spreads using an equal sample for the noncrisis period versus the average spread for each portfolio in the respective crisis period but using the data form a previous crisis phase (credit crisis is compared with data of equal size with the subprime phase and the ESD takes data form the Subprime and credits phases respectively). ***1%; **5%; and *10% significance

Panel A-NNB matching noncrisis period

Country	Subprime	NNB	ATET	Credit	NNB	ATET	ESD	NNB	ATET	GFC	NNB	ATET
All	28.18	17.53	10.65	23.87	-5.34	29.21	68.42	2.31	66.10***	49.05	-21.73	70.78***
Developed	-6.34	-52.08	45.74***	-21.57	-29.16	7.58	27.95	-4.34	32.29**	8.90	-62.05	70.95***
Emerging	275.97	312.07	-36.10	350.04	267.36	82.68***	358.86	275.67	83.19***	337.25	254.39	82.86***
Euro	9.04	-72.30	81.35***	-5.13	34.54	-39.66*	71.23	3.42	67.81***	39.65	-64.33	103.98***
Local	31.45	-1.18	32.62	20.09	-11.78	31.87	51.64	21.85	29.79***	39.89	-28.15	68.05***
USD	280.46	344.73	-64.27**	563.91	284.89	279.02***	326.35	340.27	-13.92	367.80	218.31	149.49***
Local Developed	-22.07	-59.68	37.61*	-37.45	-59.74	22.29	-17.73	-30.12	12.39	-23.11	-68.94	45.83***
Local Emerging	282.11	276.79	5.32	289.60	279.63	9.97	376.60	326.29	50.31***	335.01	316.46	18.54
PIIGS	26.53	109.06	-82.53	27.36	169.10	-141.74**	242.03	50.09	191.94***	143.60	3.40	140.20***

Panel B-Unequal sample noncrisis period

Country	Subprime	Unequal	Difference	Credit	Unequal	Difference	ESD	Unequal	Difference	GFC	Unequal	Difference
All	28.18	-50.00	78.18***	23.87	-50.00	73.87***	68.42	-50.00	118.41***	49.05	-50.00	99.05***
Developed	-6.34	-87.67	81.33***	-21.57	-87.67	66.10***	27.95	-87.67	115.62***	8.90	-87.67	96.57***
Emerging	275.97	220.42	55.55***	350.04	220.42	129.62***	358.86	220.42	138.44***	337.25	220.42	116.83***
Euro	9.04	-68.89	77.93***	-5.13	-68.89	63.76***	71.23	-68.89	140.12***	39.65	-68.89	108.54***
Local	31.44	-50.24	81.68***	20.09	-50.24	70.32***	51.64	-50.24	101.87***	39.89	-50.24	90.13***
USD	280.46	261.59	18.86	563.91	261.59	302.32***	326.35	261.59	64.76***	367.80	261.59	106.21***
Local Developed	-22.07	-107.14	85.07***	-37.45	-107.14	69.69***	-17.73	-107.14	89.40***	-23.11	-107.14	84.03***
Local Emerging	282.11	216.30	65.81***	289.60	216.30	73.30***	376.60	216.30	160.29***	335.01	216.30	118.71***
PIIGS	26.53	-63.15	89.68***	27.36	-63.15	90.51***	242.03	-63.15	305.18***	143.60	-63.15	206.74***

Panel C-Equal sample noncrisis period

Country	Subprime	Equal	Difference	Credit	Equal	Difference	ESD	Equal	Difference	GFC	Equal	Difference
All	28.18	-68.53	96.71***	23.87	-65.29	89.16***	68.42	-77.31	145.73***	49.05	-49.18	98.23***
Developed	-6.34	-101.06	94.72***	-21.57	-97.85	76.28***	27.95	-111.19	139.14***	8.90	-81.98	90.89***
Emerging	275.97	164.96	111.01***	350.04	168.42	181.62***	358.86	165.87	192.99***	337.25	186.28	150.97***
Euro	9.04	-90.92	99.96***	-5.13	-87.62	82.49***	71.23	-107.51	178.74***	39.65	-76.99	116.64***
Local	31.44	-62.68	94.12***	20.09	-59.31	79.39***	51.64	-65.93	117.57***	39.89	-41.01	80.90***
USD	280.46	189.74	90.71***	563.91	189.47	374.44***	326.35	207.92	118.43***	367.80	255.21	112.59***
Local Developed	-22.07	-111.37	89.30***	-37.45	-108.28	70.83***	-17.73	-114.54	96.81***	-23.11	-86.37	63.27***
Local Emerging	282.11	165.43	116.69***	289.60	170.10	119.50***	376.60	161.80	214.80***	335.01	171.49	163.52***
PIIGS	26.53	-81.03	107.56***	27.36	-77.39	104.75***	242.03	-100.67	342.70***	143.60	-70.72	214.31***

Panel D-Overlapping sample with previous crises periods (Credit and ESD)

Country	Credit	Overlapping	Difference	ESD	Overlapping	Difference
All	23.87	33.35	-9.48	68.42	14.91	53.50***
Developed	-21.57	-1.70	-19.87	27.95	-23.21	51.16***
Emerging	350.04	284.98	65.06**	358.86	288.52	70.34***
Euro	-5.13	13.58	-18.71	71.23	-7.65	78.88***
Local	20.09	37.02	-16.93	51.64	15.16	36.48***
USD	563.91	288.64	275.26***	326.35	377.48	-51.13*
Local Developed	-37.45	-17.28	-20.17	-17.73	-38.83	21.09***
Local Emerging	289.60	291.34	-1.74	376.60	268.02	108.57***
PIIGS	27.36	31.85	-4.49	242.03	14.56	227.47***

Table 6-Robustness checks for ATET on portfolios

This table reports the results from matching the inverse cumulative probabilities (propensity scores) which are obtained by applying equation (8) to the predicted probabilities obtained from the logit regressions for each of the (9) portfolios during the whole GFC period. The results reported in the NNB, Gauss and EPNK columns correspond to the Average Treatment Effect on the Treated (ATET) which is the difference between the crisis period average monthly spread vectors and the counterfactual vectors for each country. These results are obtained using equation (12) in the case of the NNB and equations (14) and (15) in Appendix A when using Gaussian (GAUSS) and Epanechnikov kernels as outlined in section V. The statistical significance of the ATET is tested using an ANOVA test for equality of means of the vector containing the observations of a crisis periods and their respective vector of counterfactuals using three matching methods (NNB, GAUSS and EPNK). For motives of space we do not report the average of each counterfactual vector as shown in table 5, just the final ATET result for each method. ***1%; **5%; and *10% significance.

	Subprime			**Credit**			**ESD**			**GFC**		
Country	**NNB**	**GAUSS**	**EPNK**	**NNB**	**GAUSS**	**EPNK**	**NNB**	**GAUSS**	**EPNK**	**NNB**	**GAUSS**	**EPNK**
All	10.65	35.15**	33.08**	29.21	31.81*	39.95**	66.10***	63.96***	72.13***	70.78***	73.43***	81.57***
Developed	45.74***	39.55	31.96**	7.58	8.85	7.40	32.29**	40.42***	39.88**	70.95***	65.43***	66.23***
Emerging	-36.10	-5.85	-6.68	82.68***	80.35***	73.34***	83.19***	92.63***	92.24***	82.86***	90.22***	93.80***
Euro	81.35***	69.81	68.37***	-39.66*	-50.01*	-47.61	67.81***	64.67***	86.08**	103.98***	98.15***	51.25***
Local	32.62	38.85	44.25***	31.87	22.54	28.38*	29.79***	39.52***	40.20***	68.05***	69.76***	65.87***
USD	-64.27**	-50.47	-52.10***	279.02***	281.64***	270.52***	-13.92	20.61**	12.31	149.49***	142.52***	154.17***
Local Developed	37.61*	30.35	26.26*	22.29	25.33*	23.57	12.39	11.81*	9.12	45.83***	47.78***	40.56***
Local Emerging	5.32	2.91	0.93	9.97	-7.80	2.68	50.31***	48.60***	30.73***	18.54	14.32	-5.55*
PIIGS	-82.53	-24.05	-24.79***	-141.74**	-163.04***	-144.89***	191.94***	198.42***	251.98***	140.20***	159.67***	110.18***