Regime-Dependent Sovereign Risk Pricing during the Euro Crisis*

Anne-Laure Delatte[†], Julien Fouquau[‡], Richard Portes[§]

December 12, 2014

Abstract

We test for regime-dependent dynamics in the sovereign bond markets of European peripheral countries during the debt crisis and explain them. Our estimates based on a panel smooth threshold regression model during January 2006 to September 2012 show : 1) Peripheral sovereign spreads are subject to significant nonlinear dynamics. 2) The deterioration of banking risk changes the way investors price risk of the sovereigns. 3) The spreads of European peripheral countries have been priced above their historical values, given fundamentals, because of amplification effects. 4) A key indicator regulators may want to monitor to check the sovereign tensions is the premium of financial i-Traxx CDS indices. 5) The estimated thresholds to trigger the crisis regime are quite low at less than 200 bp.

Key Words : European sovereign crisis, Panel Smooth Threshold Regression Models, CDS indices.

J.E.L Classification: E44, F34, G12, H63, C23.

*Previous versions of this paper were presented at seminars in Federal Reserverve of New York, Bank of England, Banque de France, London Business School, Nanterre University, the International Finance, Banking Society 2013 conference and the Graduate Institute Geneva. We are grateful for comments from seminars participants. We would like to acknowledge helpful discussions with Vincent Bouvatier, Markus Brunnermeier, Isabelle Couet, Jérôme Creel, Darrell Duffie, Linda Goldberg, Frédéric Malherbe, Mathiew Plosser, Lisa Pollack, Héléne Rey, Giovanni Ricco, Or Shachar and Paolo Surico. This research was partly supported by a grant from the London Business School RAMD fund and from the EU 7th Framework Program (FP7/ 2007-2013) under grant agreement 266800 (FESSUD).

[†]CNRS, OFCE, CEPR

[‡]Neoma Business School

[§]London Business School, CEPR

1 Introduction

Financial market participants have a particular taste for locutions that describe the dynamics of asset prices. In 2011, when sovereign spreads for European peripheral countries successively soared, bond market participants asserted the presence of a *cliff risk*, the point at which a small shift in a bond's value can have a big impact on its price.[1] A similar pattern was emphasized by policymakers (with different terminology) when they complained about growing mistrust on the part of investors, a fact that drove *self-reinforcing* dynamics.[2] A way to picture these comments is to say that the sovereign risk pricing is regime-dependent and subject to threshold effects. It is clear from the first graph in Fig. 1, which plots spreads between 10-year peripheral and German sovereign bonds, that the trend breaks after 2010, a break that is hard to reconcile with the gradual deterioration of economic conditions.[3]

There has been an extensive body of papers examining the sovereign bond price in the context of the euro crisis and we have learned several important lessons. First, the massive holding of peripheral sovereign bonds by the European banking sector created a dangerous nexus between sovereigns and banks implying feedback loops (Gennaioli *et al.*, 2010, Huizinga and Demirguc-Kunt, 2010, Acharya and Steffen, 2013, Acharya *et al.* , 2014, Coimbra, 2014). Second, adverse liquidity effects on euro area banks have been documented during the crisis, including a significant fall of inter-bank loans after mid-2010 (Allen and Moessner, 2013). The four first graphs in Figure 2, which plot measures of the liquidity premium, indicate that liquidity conditions in the euro-area did not recover since the sub-prime cri-

[1] See for example "Bond investors fear cliff risks.", Financial Times, November 7, 2011.

[2] "The Greek financial crisis: From Grexit to Grecovery", Speech by Mr George A Provopoulos, Governor of the Bank of Greece, for the Golden Series lecture at the Official Monetary and Financial Institutions Forum (OMFIF), London, 7 February 2014.

[3] In Spain, for example, the public debt amounted to less than 60% of GDP even by end 2009. The Italian primary budget surplus implied that if interest rates had stayed low, only modest fiscal adjustment would have been necessary to service the debt. Unemployment and the trade deficit had been increasing gradually. And Ireland's trade balance had been improving at the time of the crisis.

sis, with a clear drop in liquidity from 2011 until the Outright Monetary Transactions (OMT) measures. Third, previous empirical work document a regime-switch in the spread determination model for euro-area peripheral sovereigns during the crisis (Aizenman *et al.* (2011), Gerlach *et al.* (2010), Montfort and Renne (2012), Borgy *et al.* (2011), Favero and Missale (2011)). Two different regimes have been described, a crisis and a non-crisis regime, with additional fundamental factors important in the crisis regime. However the existing papers do not explain what drove the change in regime.
Here we explore the possibility that initial shocks on economic fundamentals may have been exacerbated by endogenous mechanisms. We can think of two potential explanations for self-reinforcing effects: the nexus between sovereign and bank risk leading to feedback loop effects and liquidity spirals implying self-amplifying dynamics.

These questions require testing for regime-switching dynamics in bond spread determination and investigating the triggers. To do so, we use the smooth transition regression model developed by Terasvirta (1996) and developed in panel by González *et al.* (2005). Contrary to the alternative family of nonlinear models, the Markov-switching (MS) models, the STR model offers a parametric solution to account for nonlinearity by allowing the parameters to change smoothly as a function of an observable variable (MS specifications assume that the transition is discrete and the trigger variable is unobserved). In other words, we take an off-the-shelf model estimating the impact of economic fundamentals on the spread of sovereign bonds, and we consider potential threshold variables to account for the time variability of the estimated coefficients. We interpret increasing weights in the spread determination as amplification effects in the sense that the same change in a fundamental has a higher impact on the spread in the crisis period than it had previously. Then we follow Gonzalez *et al.* (2005) to identify the optimal threshold variable. In sum, our panel threshold regression framework establishes a ranking among hypotheses that might give rise to amplification effects (Fouquau *et al.* 2008). We estimate equations for the sovereign spreads of five European stress countries: Spain, Ireland, Italy, Portugal and Greece, over the period January 2006 to September 2012. We deliberately end our sample at the beginning of the OMT programme that has successfully narrowed the spreads and blurred market signals.[4]

A preview of our results is the following. We confirm that sovereign spreads are subject to significant nonlinear dynamics. While we unambiguously detect adverse self-reinforcing liquidity effects, our tests reveal that the banking-sovereign nexus is the leading driver of nonlinearities. The deterioration of market conditions for financial names changes the way investors price risk of the sovereigns. We compute the threshold value that triggers amplification effects in the spreads of the five stress countries, with heterogeneous dynamics that our PSTR approach enables us to capture.

Our work complements earlier research on sovereign credit risk during the euro crisis (Acharya et al. 2013, Attinasi et al.2009, Dieckman and Planck, among others). We show that market liquidity and banking credit risk not only are significant drivers of sovereign risk but they contribute to it in a nonlinear manner. They actually exacerbate the effect of initial shocks to the fundamentals as theory predicts. We show that aggregate financial variables have a larger impact than country specific variables on the risk-pricing of domestic debt, a result that emphasizes the issues of maintaining an incomplete monetary union.

The remainder of this paper is organized as follows. Section 2 reviews the abundant literature on sovereign bond pricing during the euro-crisis in order to narrow down our contribution. Section 3 introduces the PSTR specification methodology and the test procedure. Section 4 summarizes our data-set, and Section 5 discusses the estimation results. Section 7 sums up the findings and draw lessons for the economic policy.

[4]As Pâris and Wyplosz (2013) have argued, "Spreads no longer show us what investors think about debt sustainability. They reflect a mix of debt-sustainability expectations and forecasts of ECB reactions".

2 Sovereign risk pricing: what have we learned?

There has been an extensive body of papers examining the sovereign bond price in the context of the euro crisis. On the one hand, there is a consensus about a sovereign-banking nexus implying feedback loops in the dynamics of the sovereign spreads. Acharya *et al.* (2014) has explicitly modeled the feedback loop. The deterioration of the sovereign's creditworthiness feeds back onto the financial sector, reducing the value of its guarantees and existing bond holdings and increasing its sensitivity to future sovereign shocks. On the other hand, bank risk affects the sovereigns, which are expected to bail out systemically important institutions. That represents a significant risk given the size of banks compared to the size of the public backstop. Coimbra (2014) shows how the initial shock is exacerbated and feeds back to credit conditions. After a rise in sovereign risk, the banks' VaR constraint binds, which reduces their demand for sovereign bonds, thereby raising the sovereign risk premium. This in turn leads to adverse sovereign debt dynamics, which raises sovereign risk.

Attinasi et al. (2009) empirically confirm the effect of the bank-sovereign nexus in a model of government bond yield spreads over Germany of 10 European countries. They find that government bond yield spreads are significantly affected by the announcements of bank rescue packages in addition to standard measures of government creditworthiness. Acharya *et al.*(2013) find that credit default swap (CDS) spreads of banks and those of governments tend to move more closely together after the announcement of financial sector bailouts.[5]

On the other hand, liquidity spirals have played an important role during the euro crisis. More precisely liquidity spirals occurs when an initial

[5]Several papers have focused on the opposite direction of the feedback loop: Acharya and Steffen (2013) find that the Eurozone banks actively engaged in a 'carry trade' in the crisis period, increasing their exposure to risky sovereign debt. Gennaioli *et al.* (2010) argue that the sovereign risk affects the banks through their exposure to sovereign bonds. Huizinga and Demirguc-Kunt (2010) provide evidence in a large cross-country sample that bank CDS spreads responded negatively to the deterioration of government finances in 2007-08.

shock on sovereign bonds degrades the quality of collateral, a fact that forces banks to sell off bonds to regain liquidity or restore their capital ratio, reinforcing the initial downgrading. As an example of a fire-sale driven by more restrictive collateral requirement, in November 2010, a sell-off in Irish bonds was driven by a fire sale of positions by market participants who were unable to meet collateral requirements.[6] Pelizzon et al. (2014) have documented a similar spiral on the Italian sovereign bond market. They find threshold effects in the dynamic relationship between changes in Italian sovereign credit risk and liquidity: there is a structural change in this relationship above 500 basis points (bp) in the CDS spread because of changes in collateral and margins for Italian bonds. Brunnermeier *et al.* (2009) have theoretically modeled the liquidity spirals.[7] The pricing of debt becomes more "information sensitive", and safe assets become less safe, so investors are more selective about the quality of assets they accept as collateral. Their demand for the sovereign bonds that are perceived to be more risky declines, thereby raising the sovereign risk premium. So there is a liquidity spiral: a falling sovereign bond market leads financial intermediaries to fly to liquidity, and this amplifies the effects of the initial price reduction. Relatively small shocks can cause liquidity suddenly to dry up, leading to a major correction of asset prices (Brunnermeier and Pedersen, 2009).

In total, we have learned that banking credit risk and liquidity deterioration exercised a negative influence on sovereign credit risk during the euro crisis. However the theoretical models mentioned above rather point to amplification effects where both risks exacerbate the effect of shocks to the determinants on risk-pricing. Therefore we think that handling these variables like extra determinants on the rhs of sovereign risk-pricing model is misleading. In this work, we will test the hypotheses that the deterioration of banking risk and liquidity shocks have self-reinforcing effects on sovereign pricing. Before proceeding, we conclude the review of the literature by examining existing evidence of nonlinearities in the Euro-area sovereign bond

[6] "Irish bond yields leap after selling wave", Financial Times, 10 November 2010.

[7] Stiglitz (1982) and Geanakoplos and Polemarchakis (1986) initially pointed out this externality.

spread.

Several papers have pointed to important nonlinearities in the risk-pricing of European countries. Yet, no one offers a satisfying framework to explain regime-shifts, time-varying determinants weights in the relationship and more importantly to relate them to the influence of financial variables. Several empirical papers find a regime-switch in the spread determination model for euro-area peripheral sovereigns during the crisis (Costantini et al., Aizenman *et al.* (2014), Gerlach *et al.* (2010), Montfort and Renne (2012), Borgy *et al.* (2011), Favero and Missale (2011)). For example, Costantini et al. (2014) find evidence for a level break in the cointegrating relationship of sovereign bond yield spreads in nine economies of the European Monetary Union. They also find significant differences in the coefficient weight of fiscal space in determining sovereign risk in peripherals versus core EMU members. They attribute this difference to the fact that international investors perceive which EMU member legitimately entitles for Optimal Currency Area member. As intellectually appealing it may be, their interpretation cannot be tested in their empirical framework because it does not allow them to test the potential drivers of observed nonlinearities. Our objective in this paper is to relax linearity and allow the spread determination model to change according to an *observable signal* that sets off amplifying spirals. In the following Section, we describe our empirical strategy to do so.

3 Empirical strategy: specification and estimation

We estimate sovereign bond spread determination using a panel smooth threshold regression (PSTR) model developed by Gonzáles *et al.* (2005). The choice of panel data is motivated by the low time dimension of macroeconomic data. The PSTR model allows us to characterize nonlinearity as a function of an observable variable. More precisely, the sovereign spread can be estimated as follows:

$$S_{it} = \mu_i + \beta_1' X_{it} + \beta_2' X_{it} g(q_{it}; \gamma, c) + u_{it} \quad (1)$$

for $i = 1, \ldots, N$ and $t = 1, \ldots, T$ where μ_i represents individual fixed effects, X_{it} is a set of variables that capture credit risk, liquidity risk and international risk aversion and u_{it} are i.i.d. errors. $g(.)$ is a continuous transition function bounded between 0 and 1. We use a logistic function of order 1 that has an S shape:

$$g(q_{it}; \gamma, c) = \frac{1}{1 + \exp\left[-\gamma(q_{it} - c)\right]} \;, \gamma > 0. \tag{2}$$

where q_{it} is the observable threshold variable. The γ parameter determines the smoothness, *i.e.,* the speed of the transition from one regime to the other, and c the location parameter, which shows the inflexion point of the transition. The higher the value of the γ parameter, the faster (*i.e.*, sharper) the transition. This specification allows a smooth transition between two extreme regimes defined by the vectors β_1' and $\beta_1' + \beta_2'$. For example, if we take a threshold variable that proxies *flight to liquidity*, the higher this proxy, the closer the coefficient gets to $\beta_1' + \beta_2'$. The PSTR model is a way to account for individual heterogeneity (Fouquau *et al.*, 2008).

The estimation of the PSTR model consists of several stages. In the first step, a null hypothesis of linearity is tested against the alternative hypothesis of a threshold specification. Then, if the linear specification is rejected, the estimation of the parameters of the PSTR model requires eliminating the individual effects, μ_i, by removing individual-specific means and then applying nonlinear least squares to the transformed model (see González *et al.*, 2005).

In the González *et al.* (2005) procedure, testing linearity in a PSTR model (equation 1) can be done by testing $H_0 : \gamma = 0$ or $H_0 : \beta_0 = \beta_1$. In both cases, the test is non-standard since the PSTR model contains unidentified nuisance parameters under H_0 (Davies, 1987). The solution is to replace the transition function, $g(q_{it}; \gamma, c)$, with its first-order Taylor expansion around $\gamma = 0$ and to test an equivalent hypothesis in an auxiliary regression. We then obtain:

$$S_{it} = \mu_i + \theta_0 \ X_{it} + \theta_1 \ X_{it} q_{it} + \epsilon_{it}^*. \tag{3}$$

In these auxiliary regressions, parameter θ_1 is proportional to the slope parameter γ of the transition function. Thus, testing linearity against the PSTR simply consists of testing $H_0 : \theta_1 = 0$ in (3) for a logistic function with the usual LM test. The corresponding LM statistic has an asymptotic $\chi^2(p)$ distribution under H_0.

Before proceeding to the estimation, we present our data.

4 Data description

In this Section we present our dataset and sources used to estimate the linear model of sovereign bond spreads and to construct the threshold variables that capture the forces described in Section 3.

The estimation of the model of Eq.(1) is subject to two major data constraints. On the one hand, macroeconomic fundamentals have a low frequency (annual, quarterly or monthly), while our financial data are daily. Therefore we transform all series to monthly data. We calculate the monthly average of the daily series and we transform quarterly to monthly using a local quadratic transformation with the average matched to the source data[8]. On the other hand, the sovereign crisis started in late 2009, and the Outright Monetary Transactions (OMT) program implemented in September 2012 successfully narrowed the spreads and blurred market signals. So we have only three years during which the hypothesized transition might have occurred. Therefore, to obtain a sufficient number of observations, our estimation is based on a balanced panel of the five peripheral European countries in which the sovereign yield has been most under pressure (Greece, Ireland, Italy, Spain and Portugal) between January 2006 and September 2012.

4.1 Determinants of the sovereign bond spread

Our dependent variable is the sovereign bond spread, which prices the default risk of a country. It is defined as the difference between the sovereign bond yield and the risk-free rate of the same maturity. For each country

[8] We used Eviews software for this transformation.

in the sample, we use the long-term German yield, which is the benchmark risk-free rate for the Euro area (Dunne *et al.*, 2007), and the government yield of this country at the same maturity. We rely on daily observations of 10-year bond yields provided by Bloomberg, from which we compute a monthly average[9]. All data described in this Section are plotted in Figure 1.

A key choice is the set of explanatory variables included in X_t in Eq (1). The government bond yield spread represents the risk premium paid by governments relative to the benchmark government bond[10]. From a theoretical perspective, these instruments can be priced by decomposing the risk premium into credit risk and liquidity risk. Credit risk is influenced by variables that affect the sustainability of the debt and the likelihood of repayment. For a sovereign entity, these are macroeconomic variables determining internal and external balances, more precisely variables important in determining the budget deficit and the current account. The empirical evidence in the euro area context suggests that significant determinants include fiscal variables, activity-related and competitiveness-related variables (see Attinasi *et al.* 2009, Haugh *et al.* 2009, De Grauwe and Ji, 2012). Liquidity risk is related to the size of the issuer, with an expected negative relationship due to larger transaction costs in small markets. In contrast with findings on credit risk, empirical evidence is mixed about the pricing of a liquidity premium in the sovereign bond spread[11]. Beyond these two theoretical risk premia, Longstaff et al (2011) find that a large component of sovereign credit risk is linked to global factors, while Ang and Longstaff (2013) find that the systemic default risk of European countries is highly correlated to financial market variables.

Drawing on previous works, we therefore test the following variables:

[9]For Ireland only 8-year bond yields are available, so we computed the spread using the 8-year German yield.

[10]Early and influential empirical papers include Edwards (1986), Eichengreen and Portes (1989), Cantor and Packer (1995).

[11]For example, Geyer *et al.* (2004) finds that liquidity plays a minor role for the pricing of EMU government yield spreads. Favero *et al.* (2009) find that investors value liquidity, but they value it less when risk increases.

debt-to-GDP ratio, deficit, unemployment, unit labor cost, risk, liquidity.

We include the debt-to-GDP ratio and fiscal deficit from Eurostat. We add the squared value of the debt-to-GDP ratio to capture non-linear dynamics that might be due to threshold effects of sovereign debt on real growth. The fiscal data are revised data, necessary because of the presence of Greece in the sample, although these are not the data initially observed by market participants. Other relevant variables are economic activity and the country's competitiveness. We proxy economic activity using the unemployment rate rather than GDP to avoid collinearity with the debt-to-GDP ratio. The unit labor cost and trade balance are included to proxy the country's competitiveness.[12] Second, we include a variable for liquidity risk, proxied as the bid-ask spread of the dependent variable and alternatively measured by market size, as the country's share of total outstanding Euro-denominated long-term government securities issued in the Euro zone. Data are available on a monthly basis from the European Central Bank (ECB), while the bid-ask spread is taken from Bloomberg. Third, we include the CBOE Volatility Index (VIX) as a measure of international risk aversion, because it is often considered by many to be the world's premier barometer of investor sentiment and market volatility (*e.g.*, Rey, 2013).

Last, we control for the effect on peripheral spreads of non-standard monetary measures adopted by the ECB during the crisis. In May 2010, the ECB decided to start the Securities Markets Programme (SMP) with large securities purchases in order to address tensions in certain market segments[13]. We use the amount of securities held for monetary purposes (divided by 100), as shown in the ECB's weekly financial statements, and including Securities Market Program, 1st and 2nd Covered Bond Purchase Programs (available in ECB Statistical Data Warehouse)[14].

[12] All data are available at a quarterly frequency, except for unemployment (monthly) and fiscal deficit (annual).

[13] The SMP was terminated in September 2012 in favour of Outright Monetary Transactions (OMTs) in sovereign secondary bond markets.

[14] On the other hand, the ECB provided in December 2011 and March 2012 more than 1 trillion Euros of additional liquidity to the financial system with the very long-term refinancing operations (LTRO). Unfortunately publicly available data are not broken down

4.2 Endogenous drivers of nonlinearities, two hypotheses

We present the set of financial data used to capture our two hypotheses presented in Section 2. They represent the set of threshold variables that we will include alternatively in our nonlinear estimations in the next Section. We propose several alternatives in order to check the robustness of our results. In the following Section, we will explain how we select the optimal threshold variable. All threshold variables are plotted in Fig. 2.

1. *Feedback loop from banks to sovereigns*

   - CDS prices are a reliable measure of risk as they are precisely the premium an investor must pay to hedge the risk or express a credit view of a reference entity. CDS indices are baskets of single CDS covering specific sectors.[15] Therefore the most straightforward measure of financial risk is the price of CDS indices covering the financial risk in the euro-area, *SenFin* and *SubFin*, both being in the family of the i-Traxx Europe, a broad tradable credit default swap family of indices .

   Second, we construct disaggregate indicators of uncertainty and stress in the banking sector borrowed from an aggregate indicator of systemic risk designed by the Kansas Fed (Hakkio and Keeton, 2009). More precisely, we compute components of their indicator with European data:

by country, which makes the inclusion of the data composed of two observations irrelevant in our panel estimates.

[15] The main advantages of these new classes of credit derivatives are standardization and liquidity, which explain their growth. CDS indices accounted for 43% of gross notional amount of the CDS market in December 2012, up from 20% in 2004 (Vause, 2011). CDS trading has continued to grow after 2007 (IOSCO, 2012). At the end of 2012, the gross notional value of outstanding CDS contracts amounted to approximately 25 trillion US dollars, and the corresponding net notional value to approximately 2.5 trillion US dollars. The fact that the gross notional value of the CDS contracts has more than halved since the peak of 2007 (with 60 trillion US dollars) is mostly attributed to the development of compression mechanims that eliminate legally redundant contracts (Vause 2011).

- *IVolbank* denotes the idiosyncratic volatility of bank stock prices. It serves as an equivalent of the VIX for the banking industry rather than for the corporate sector as a whole. It is computed as the standard deviation of residual returns from a CAPM regression using an aggregate European banking sector price index and the S&P Europe 350 taken from Datastream.

- *CMAXFin* is an indicator of stress widely used by market practitioners to identify periods of extreme price declines (Patel and Sarkar (1998)). We take the five domestic banking stock indices from Datastream and calculate *CMAXFin* as the maximum cumulated index losses over a moving two-year window with $Cmax_t = 1 - \frac{P_t}{max[P_{t-24}...P_t]}$. The more bearish the market, the closer to 1 the indicator.

- An additional useful indicator of stress in the banking system is the *Euribor-OIS spread*, calculated as the difference between the Euro Interbank Offered rate and the overnight indexed swap rate. This indicator must be taken with some caution because of the alleged manipulation of the Euribor rate.

2. *Negative externality due to fire-sale liquidiation*

We calculate standard indicators of *flight to liquidity* complemented by indicators of *flight to quality* and *asymmetry of information* because they occur simultaneously during a liquidity run and strengthen self-amplifying dynamics (as put in Section 2).

- *Aaa/10-year Treasury spread* denotes the spread between European corporate bonds rated Aaa and the 10-year German Treasury bond. It is a standard measure of liquidity premium, because even the highest-rated corporate bonds tend to be less liquid than Treasury securities. All corporate bond indices are Markit i-boxx European corporate bonds, taken from Datastream.

- *High-yield bond/Baa spread* denotes the spread between "junk bonds", *i.e.* bonds with too low a rating to be considered investment-grade, and Baa-rated corporate bonds, the lowest-rated bonds considered as investment-grade. High-yield bonds are issued in smaller quantities and traded by a limited set of investors (institutional investors are banned from the market) in comparison with Baa-rated bonds, implying a liquidity premium to compensate investors for holding the less liquid asset.

- *10-year swap spread*. The fixed-rate payment leg of a swap is expressed as the Treasury yield plus a spread that compensates investors for the fact that claims on fixed-rate payments are considerably less liquid than Treasury securities.

- *StockbondsCorr* proxies *Flight to quality* by measuring the correlation between domestic stock total return indices and the total return German Treasury index. It is well-documented that the correlation between stock and government bond returns is usually significantly negative during financial crises, because investors consider government bonds safer (Andersson *et al.* 2008). We compute the correlation over rolling three-month periods using the domestic stock index of each country of our panel and the 10-year German government bond index taken from Datastream. We use the negative values of the correlations, so that an increase in the measure corresponds to higher *flight-to-quality*.

- *Cross-section dispersion bank* computes the cross-section dispersion of bank stock returns to capture uncertainty about the relative quality of banks and to proxy *asymmetry of information*. The intuition is that the larger the cross-section dispersion, the larger proportion of returns is unexpected, so the larger the information asymmetry. It is calculated using daily data on the S&P Europe 350 and the stock prices of the 82 largest commercial banks in terms of market value[16].

[16] More precisely we estimate a CAPM regression of the daily return on each bank's stock index against the daily return on the S&P Europe 350 index, using data for the previous

3. *Control Variables*

Last, we control for an overall effect of uncertainty and stress outside the banking sector by including indicators on non-financial sectors:

- *i-Traxx Europe* comprises the most liquid 125 CDS referencing European investment grade credits
- *X-over* comprises the most risky 40 constituents
- *HiVol* is a subset of the main Europe index consisting of what are seen as the most risky 30 constituents
- *Vstoxx* is the European equivalent of the VIX, considered by many to be the leading measure of market volatility[17].
- *FTSE300* and *S&P350* denote the returns of the European aggregate stock market indices
- *DomsticIndex* is the matrix of the domestic stock returns indices of the five countries in our panel (PSI, IBEX, ATHEX, FTSEMIB, ISEQ).
- *RvolGerm* captures bond market volatility using the 10-year German government bond index. It is the realized volatility computed as the monthly average of absolute daily rate changes.
- *Rvol Nonfi* is the realized volatility of domestic non-financial sector stock market indices taken from Datastream.
- *Rvoldoll*, *Rvolyen* and *Rvolpound* are the realized volatility of three bilateral euro exchange rates for the US dollar, the Japanese yen and the British pound respectively.

Looking at the set of threshold variables plotted in Fig. 2, we see that most variables experienced a first peak during the subprime crisis, followed

12 months. The estimated coefficients are then used to calculate the forecast errors of the current month. Last we calculate the interquartile range for these residuals in order to keep the central 50%. The lower the interquartile value, the smaller the dispersion across banks.

[17]We use Vstoxx to proxy the European market volatility, while we use VIX to capture international risk aversion.

by a second peak due to the sovereign debt crisis in Europe. Thus our financial series capture two episodes of crisis, contrary to our dependent variable, which is mostly affected by the second episode. This pattern represents a methodological challenge to detect the drivers of nonlinearity during the European crisis. In the following, we present our results.

5 Estimation results: Nonlinear dynamics in the European sovereign market.

We recall that the PSTR specification of the spread is as follows:

$$S_{it} = \mu_i + \beta_1' X_{it} + \beta_2' X_{it} g(q_{it}; \gamma, c) + u_{it}$$

for $i = 1, ..., n$ and $t = 1, ..., T$, X represents the vector of determinants, μ_i the country fixed effects, $g(.)$ the threshold function, q_{it} the threshold variable, γ the smooth parameter, c the location parameter.

5.1 Selection of the optimal linear model

First, we proceed to the linear estimation using a panel estimation with fixed effects. The first step is to select the optimal linear model. We use alternative series in the vector of explanatory variables and select the optimal combination based on standard selection criteria. Results displayed in Table 1 suggest that our specifications are robust with similar estimated values in different specifications. The information criteria suggest that specifications 1 and 2 could both be considered as optimal (Schwarz = 0.207, AIC = 0.197), and we keep specification 2 which is the most parsimonious.

With a negative and a positive coefficient respectively, the evolution of the sum of Debt and squared Debt is ambiguous, while trade balance is not significant. As expected, unemployment and international risk aversion have an upward impact on the spread: a rise in unemployment and in the VIX increase the sovereign spread. Liquidity effects are properly captured by our measures based on the bid-ask spread (an increase in the bid-ask spread increases the sovereign spread) and volume (a reduction of outstanding issues increases the spread). We keep both in the vector of determinants because information criteria are systematically better when both measures are included. In addition, as in other studies (De Grauwe and Ji, 2012, Wyplosz, 2013), we find that competitiveness is not relevant: the unit labor cost has an unexpected sign (higher labour cost reduces the spread) while the trade deficit is never significant. Last, in all specifications the unconventional monetary measures adopted by the ECB have a significant effect.

In the following we adopt a parsimonious approach and proceed to the tests and nonlinear estimation of specification 2.

5.2 Linearity tests: the prominent role of the feedback loop

In the second step, we test this linear specification of the spread (spec 2) against a specification with threshold effects.

The linearity test results reported in Table 2 clearly reject the null hypothesis of a linear relationship, regardless of which threshold variable is included in the specification. The remarkably high level of rejection in most models makes the presence of nonlinear dynamics unambiguous. This is consistent with previous empirical work and makes it clear that linear models of sovereign spreads are misspecified. Now, we would like to identify the prominent determinants of bond pricing shifts. To do so, we select the best threshold variables, which as suggested by González et al. (2005), is that which leads to the strongest rejection of the linearity hypothesis. Given the high rejection statistics obtained in every model, we check the robustness of our selection choice using BIC information criteria which yield overall consistent results (see Table 2 bis).

The ranking of the test statistics reveals that the feedback loop hypothesis unambiguously stands out with *CmaxiFi*, *CDSSnrFin*, *CDS SubFin*, Euribor-OIS and *IVolBank* rejecting linearity (with 194.2, 148.3, 130.9, 119.4 and 116.2 respectively).[18] It is interesting to observe that indicators of uncertainty about the *non*-financial sector, *rvol NonFin* and *rvol Germ*, rank among the last with low statistics (39.5 and 30.4 resp.).

In sum, investors are sensitive to the risk in the banking sector, and this triggers nonlinear dynamics. While the sovereign-nexus has been well-documented before, we are the first to give a functional form to the subsequent amplification effects. More precisely, the pricing model is a nonlinear function of fundamentals, where the weight of these fundamentals varies with the risk of banks (we examine the evolution of the estimated coefficient below). The deterioration of market conditions for banks changes the way investors price risk of the sovereigns.

Second, we can not reject the hypothesis of adverse effects due to fire-sale liquidation, which also gets empirical support with LM statistics from 51.2 to 111.4. *Flight to liquidity*, *Flight to quality* and *asymmetry of information* have been unambiguously relevant factors of amplification in the European sovereign debt crisis. Nevertheless, our empirical strategy ranks the influence of both hypothesis and concludes that the sovereign-nexus was prominent in driving non linearities.

Last the tests reveal that the volatility of different market segments play a less significant role in nonlinear dynamics. While the volatility of FTSE and S&P get a fairly high rejection statistics (111.8 and 111.6), other volatility measures such as Vstoxx do not confirm the effect of overall volatility (LM= 64.2). This suggests that aggregate equity indices correlate with bank stocks indices and thus convey a similar information. Volatility of the foreign exchange market is less relevant (*rvol Pound*, *rvol Doll* and *rvol Yen* get 49.5, 40.0 and 43.9 resp) probably because intra-Euro zone, not extra-Euro zone capital transfers have been relevant since 2010 (IMF, 2012a). Peripheral countries have suffered massive capital flight back to the core countries, resulting in monetary fragmentation of the euro-zone. But the aggregate external position of the eurozone has not deteriorated significantly.

[18] The BIC information criteria confirm the selection, see Table 2 bis

In the last step of our empirical investigation, we estimate the models to compute the threshold values triggering regime switch and the variation of coefficient loads.

5.3 Heteroegeneity in the sample

Table 3 reports the linearity test statistics, the smooth parameter, γ, the location parameter c and the residual sum of squares in the three specifications that best reject linearity.

According to the selection criteria of González *et al.* (2005), the indicator of stress in the banking sector , *CmaxFi* is the optimal threshold variable because it rejects linearity with the highest statistics. This is also confirmed by the information criterion (Schwarz : -0.485In this specification the smooth parameter is high ($\gamma = 111.4$), implying a sharp transition between two extreme regimes. However, a thorough investigation indicates that this variable *CmaxFi* captures the heterogeneity in our sample. In fact, Italy, Spain and Portugal remain exclusively in the first regime (in these countries *CmaxiFi* is always lower than the estimated location parameter $c = 0.819$ as shown in Fig 2, graph entitled max Financials), while Ireland and Greece went from the first to the second regime (47 and 12 observations respectively as shown in Fig 2). Heterogeneity in the sample is confirmed also in the specification including an individual threshold variable, *Ivol Bank*, with similar patterns: the transition is sharp ($\gamma = 141.0$), and only Ireland and Greece went from the first to the second regime (27 and 12 observations respectively as shown in Fig 2, graph *Ivol Bank*).

Therefore, while the five peripheral countries are usually gathered in the same bundle, our estimates suggest that their spreads have a different dynamics. [19] This finding leads us to split our sample into two sub-samples, one including Italy, Spain and Portugal, the other Greece and Ireland. The

[19] González-Hermosillo and Johnson (2014) also point out heterogeneous dynamics in the sovereign CDS of the five stressed countries.

smaller sub-sample still has 162 observations, which is sufficient for reasonably precise and stable estimates.

We re-estimate the model in each sub-sample (Table 4) and find that linearity is strongly rejected again with a slightly different ranking from the full sample.[20] What is the threshold value and how do elasticities change? To answer, we estimate $\hat{\beta}_1$ and $\hat{\beta}_2$ in Eq. (4) and we compare the determinants coefficients before and after the transition, $\hat{\beta}_1$ and $\hat{\beta}_1 + \hat{\beta}_2$ respectively. We adopt a general-to-specific modeling approach where we eliminate non-specific variables based on their statistical significance and the Schwartz information criterion.

5.3.1 Italy, Portugal and Spain

Results in Table 5 report the estimated coefficients in regime 1 and regime 2 ($\hat{\beta}_1$ and $\hat{\beta}_1 + \hat{\beta}_2$). First, it indicates that the transition from the first to the second regime is sharp ($\gamma = 53.7$) and the threshold value, c is 135.7 bp. Our model predicts that investors price the sovereign risk differently when the financial CDS index is over 135.7 bp. It is worth noting that this value was crossed in autumn 2010 just after the Greek crisis broke. [21] Now we examine the variation of the coefficient. Recall that amplification can be modeled through increasing weights in the spread determination.

Our estimates suggest amplification effects that operate in regime 2 through a much stronger influence on the spread of all macroeconomic determinants: debt, fiscal balance and unemployment as well as the international risk aversion ($\mid \hat{\beta}'_1 + \hat{\beta}'_2 \mid > \mid \hat{\beta}'_1 \mid$). In other words, when the price of iTraxx *CDS SnrFin* exceeds 135.7 bp, the weight of these fundamentals increases

[20] In fact, in both samples, *CDSSnrFin* and *CDS Sub-Fin* best reject linearity (LM =88.2/82.8 and 67.3/61.9 resp), while *CmaxFi* ranks lower. This result confirms that the individual variable *CmaxFi* was mostly capturing heterogeneity in our previous estimates (as was *IvolBank*). In turn, *CDS SnrFin* and *CDS Sub-Fin*, which are two homogeneous variables, account for the time-instability in the spread determination model.

[21] In the alternative model $\gamma = 2.18$ which corresponds to a sharp transition too, see Table 5.

in the determination model, so the shocks to fundamentals have more effect on the bond spread. It is worth observing that the coefficients in the second regime are much larger, often more than twice as much as in the first regime. In sum, we detect sizable amplification effects.[22] Last, we observe that the influence of the SMP program has not changed during the crisis.

5.3.2 Greece and Ireland

Results of the second sub-sample including Greece and Ireland are reported in Table 7. Transition is sharp and the threshold value is 155 bp, a value similar to the previous sub-sample.[23] However, the dynamics differ here because amplification effects operate through a stronger influence of unemployment only. In turn, the effects of debt and squared debt compensate for each other, while the effects of the VIX and of the bid-ask spread are positive, as expected, but they remain stable in the second regime. As in the linear estimate, the unit labor cost has the same unexpected sign. An interesting difference is that contrary to the previous sample, we observe that the SMP has a negative effect on the spread in the second regime ($\hat{\beta}_1' + \hat{\beta}_2' < 0$). In other words, our estimates suggest that the bond purchases carried out by the ECB have counterbalanced amplification effects on the bond spreads of Greece and Ireland.

[22]In turn, the influence of liquidity is ambiguous because the coefficients of both variables capturing liquidity show two contrary movements in regime 2 : we find a stronger negative influence of the relative stock of outstanding debt (implying that a deterioration of liquidity affects the spread more in regime 2 than in regime 1), while the influence of the bid-ask spread is lower in the second regime ($| \hat{\beta}_1' + \hat{\beta}_2' | > | \hat{\beta}_1' |$, implying that a rise in the bid-ask spread affects the spread less in regime 2). In addition, we observe that the sign on unit labor cost is contrary to the expected sign, as in the linear estimates (see Table 1). As in the linear estimates, models excluding this variable have a lower RSS, so we decide to keep it in the vector of explanatory variables.

[23]The transition speed depends on γ and the distance between the threshold variable and the threshold parameter c. Despite the low value of the slope parameter ($\gamma = 0.43$), the fact that CDS indices increase strongly during the crisis implies that the transition from one regime to the other is fairly fast, as in the other sub-sample.

Robustness

To check the robustness of our estimates, we proceed to alternative estimates. In the first sub-sample (including Italy, Spain and Portugal), overall amplification effects are confirmed when *Cmax Fin* is used as a threshold variable in an alternative specification (see Table 6).[24] Second, financial CDS and sovereign bonds may price the same information, which would raise an endogeneity bias due to simultaneity. To address this, we re-estimate our optimal model by lagging the threshold variable. Linearity is rejected with a similar statistic ($LM = 63.2$ versus 62 in the core estimate), and amplification effects are confirmed. Last, we check that our nonlinearity finding does not result from omitting the financial CDS index as an explanatory variable. Our results are not affected by the introduction of the financial CDS index in the vector of determinants (X_{it} in Eq. 4), a result that confirms that this variable nonlinearly affects the sovereign bond pricing.[25]

In the second sub-sample (including Greece and Ireland), we proceed to the same alternative estimates reported in Table 8. Model 1 confirms the stronger influence of debt and unemployment and indicates a stronger influence of liquidity, a result not uncovered in the core estimates. The downward influence of the SMP is confirmed too.

6 Concluding remarks

We estimated the sovereign spread of five peripheral members of the euro-area using panel non-linear estimation methods. Our objectives were three-fold: 1) test for nonlinear sovereign bond pricing 2) discriminate between two potential drivers of non-linearity, sovereign-bank nexus and liquidity spirals and 3) quantify the threshold effects and coefficient regime shifts in order to draw lessons for economic policy.

[24]We observe that the combined influence of debt and squared debt increases in regime 2 as well as the weight of fiscal balance and unemployment. Only the influence of VIX, which is found to be stable, differs from the core estimate.

[25]Results available on request.

Our PSTR estimations confirm that investors have priced the European sovereigns differently since Fall 2010. The increasing risk in the banking sector was not only a significant determinant of sovereign risk but it amplified the initial shock on fundamentals. A key indicator the ECB may want to monitor to check the sovereign tensions is the premium of financial i-Traxx CDS indices. The estimated thresholds to trigger the crisis regime are quite low at less than 200 bp. We document amplification effects due to liquidity spirals too, although to a lesser extent. In addition, while we find unambiguously strong amplification dynamics in the sovereign bonds of Italy, Spain and Portugal, we find lower effect in Greece and Ireland. It suggest that the latter are mostly facing domestic issues while the three other peripherals are highly vulnerable to a shock at the aggregate European level. In these three countries, the elasticity of sovereign yield to a variation of most fundamental more than doubles in the crisis regime. Why should we care? Because it suggests that addressing domestic fiscal imbalances and real economy issues will lower down sovereign tensions only when the aggregate banking-sovereign nexus is definitely cleaned out. Doubts unfortunately persist about the ability of the modest banking union recently adopted to restore banking stability.

References

1. Acharya, V., and Steffen, S. "The greatest carry trade ever? Understanding Eurozone bank risks", CEPR Discussion Paper 9432 (2013).

2. Acharya, V., Drechsler, I., and Schnabl, P. "A Pyrrhic victory? Bank bailouts and sovereign credit risk", Journal of Finance, forthcoming.

3. Adrian, T., and Shin, H. S. "The Changing Nature of Financial Intermediation and the Financial Crisis of 2007-2009". *Annual Review of Economics*, 2(1), 603-618 (2010).

4. Afonso A., P. Gomes and P. Rother, "What "hides" behind sovereign debt ratings?", European Central Bank Working Paper, 711 (2007).

5. Aizenman J, M. M. Hutchison and Y. Jinjarak, "What is the risk of European sovereign debt default? Fiscal space, CDS spread, and market pricing of risk", NBER WP 17407 (2011).

6. Allen, W. A. and Moessner, R. "The liquidity consequences of the euro area sovereign debt crisis". BIS Working Paper (2013).

7. Andersson, M. Krylova, E. and Vahamaa, S. "Why Does the Correlation between Stock and Bond Returns Vary over Time?", *Applied Financial Economics*, 18(2) (2008).

8. Arghyrou, M. G. and Kontonikas, A., "The EMU sovereign-debt crisis: Fundamentals, expectations and contagion," *European Economy - Economic Papers 436*, Directorate General Economic and Monetary Affairs, European Commission (2011).

9. Attinasi, M. G., Checherita, C. and Nickel, C., "What explains the surge in euro area sovereign spreads during the financial crisis of 2007-09?", ECB Working Paper (2009).

10. Baba, N., and Inada, M., "Price discovery of subordinated credit spreads for Japanese mega-banks: Evidence from bond and credit default swap markets". *Journal of International Financial Markets, Institutions and Money*, 19(4), 616-632 (2009).

11. Bernanke, B., Gertler, M. and Gilchrist, S. "The financial accelerator in a quantitative business cycle framework." *Handbook of macroeconomics* 1 1341-1393, (1999).

12. Blanco, R., Brennan, S. and Marsh, I. W., "An Empirical Analysis of the Dynamic Relation between Investment-Grade Bonds and Credit Default Swaps". *Journal of Finance*, 60, 2255-2281 (2005).

13. Borgy, V., Laubach, T., Mésonnier J.-S. and Renne, J.-P., "Fiscal Sustainability, Default Risk and Euro Area Sovereign Bond Spreads Markets", Document de travail n.350, Banque de France (2011).

14. Brock, W. A., Hommes, C. H. and Wagner, F. O. O. "More hedging instruments may destabilise markets." *J. Econ. Dynam. Cont.* 33, 1912-1928 (2009).

15. Brunnermeier, M., Crockett, A., Goodhart C., Persaud, A., Shin, H., *The Fundamental Principles of Financial Regulation*, ICMB-CEPR Geneva Reports on the World Economy series (2009).

16. Brunnermeier, M. Oehmke, M., "Complexity in financial markets", Technical report, Princeton Working Paper 2009/2, 4 (2009).

17. Brunnermeier, M. Pedersen, L.H., "Market liquidity and funding liquidity", R*eview of Financial Studies*, 22, 2201-2238 (2009).

18. Cantor, R. Packer, F., "Determinants and impact of sovereign credit ratings", FRB NY*Economic Policy Review*, 2(2) (1996).

19. Coimbra, N., "Sovereigns at risk: a dynamic model of sovereign debt and banking leverage", London Business School (January 2014).

20. Davies R.B. "Hypothesis testing when a nuisance parameter is present only under the alternative", *Biometrika* 74, 33-43 (1987).

21. De Grauwe, P., Y. Ji, " Self-fulfilling crises in the Eurozone: an empirical test", *Journal of international money and finance*, 34, 15-36 (2013).

22. De Grauwe, P.,"A fragile eurozone in search of a better governance", *CESIFO Working Paper*, n.3456 (2011).

23. De Grauwe, P., "The financial crisis and the future of the eurozone", *Bruges European Economic Policy Briefings*, 21 (2010).

24. Delatte, AL., Gex, M. and A. Lopez-Villavicencio, "Has the CDS market influenced the borrowing cost of European countries during the sovereign crisis?", *Journal of International Money and Finance*, 31(3) (2012).

25. Duffie, D. and Singleton, K., "Modeling term structures of defaultable bonds", *Review of Financial Studies*, 12(4), 687-720 (1999).

26. Dunne, P., Moore, M. and Portes, R. "Benchmark Status in Fixed Income Asset Markets." *Journal of Business Finance and Accounting* 34.9-10 1615-1634 (2007).

27. Edwards, S. "The pricing of bonds and bank loans in international markets: An empirical analysis of developing countries' foreign borrowing", *European Economic Review*, 30 (3), 565-589 (1986).

28. Eichengreen, B. Portes, R., "After the Deluge: Default, Negotiation and Readjustment in the Interwar Years", in B. Eichengreen and P. Lindert (eds.), *The International Debt Crisis in Historical Perspective* , pp. 12-47(MIT Press, 1989).

29. Favero, C., Pagano, M. and von Thadden, E.L. "How Does Liquidity Affect Government Bond Yields?", *Journal of Financial and Quantitative Analysis*, 45, 107-134 (2010).

30. Favero, C. and A. Missale, “"Sovereign Spreads in the Euro Area. Which Prospects for a Eurobond?" *Economic Policy*, 27(70), 231-273 (2012).

31. Fouquau J., Hurlin C., Rabaud I., "The Feldstein-Horioka Puzzle: a Panel Smooth Transition Regression Approach." *Economic Modelling*, 20, 284-299 (2008).

32. Geanakoplos, J. and Polemarchakis, H. "Existence, regularity and constrained suboptimality of competitive allocations when markets are incomplete", in W. Heller, R. Starr and D. Starrett (eds), *Essays in Honor of K. Arrow*, Cambridge: Cambridge University Press (1986).

33. Geanakoplos, J. "The leverage cycle." *NBER Macroeconomics Annual 2009*, Volume 24. University of Chicago Press. 1-65 (2010).

34. Gennaioli, N., Martin, A. and Rossi, S., "Sovereign default, domestic banks and financial institutions", CEPR Discussion Paper 7955 (2010).

35. Gerlach, S., A. Schulz and G.B. Wolff, "Banking and sovereign risk in the euro area", Deutsche Bundesbank Discussion Paper n.09/2010 (2010).

36. Geyer, A. Kossmeier, S and Pichler, S., "Measuring systematic risk in EMU government yield spreads", *Review of Finance*, 8(2), (171-197) (2004).

37. González A., Teräsvirta T. and D. van Dijk "Panel smooth transition regression models", SEE/EFI Working Paper Series in Economics and Finance No. 604 (2005).

38. Gorton, G. and Metrick, A., "Securitized banking and the run on repo", *Journal of Financial Economics*, 104(3), 425-451 (2012)

39. Hamilton J.D., *Time series analysis*, Princeton University Press (1994).

40. Hakkio C.S and Keeton, W., "Financial Stress: What is it? How can it be measured?", Federal Reserve Bank of Kansas City, *Economic Review* (2009).

41. Haugh, D., P. Ollivaud and D. Turner, "What Drives Sovereign Risk Premiums?: An Analysis of Recent Evidence from the Euro Area", OECD Economics Department Working Papers, No. 718, OECD Publishing (2009).

42. Hollo, D. Kremer, M. and Lo Duca, M., "CISS-a composite indicator of systemic stress in the financial system", ECB Working Paper (2012).

43. Huizinga, H., and Demirguc-Kunt, A., "Are banks too big to fail or too big to save? International evidence from equity prices and CDS spreads", European Banking Center Discussion Paper 2010-15 (2010).

44. IMF, "World Economic Outlook. Coping with High Debt and Sluggish Growth", World Economic and Financial Surveys, International Monetary Fund, Washington (2012a).

45. IMF, "Global Financial Stability Report. The Quest for Lasting Stability", World Economic and Financial Surveys, International Monetary Fund, Washington (2012b).

46. IOSCO, "The credit default swap", Technical Report, International Organization of Securities Commissions (2012)

47. Lane, P. (2012) "The European sovereign debt crisis", *Journal of Economic Perspectives*, 26(3) (2012).

48. Longstaff, F.A and Schwartz, E.S, "A simple approach to valuing risky fixed and floating rate debt", *Journal of Finance*, 50(3), 789-819 (1995).

49. Longstaff, F.A, Pan Jun, Pedersen, L.H. and Singleton K.J. , "How Sovereign Is Sovereign Credit Risk?," *American Economic Journal: Macroeconomics,* American Economic Association, vol. 3(2), pages 75-103 (2011).

50. Montfort A. and J.P. Renne, "Credit and liquidity risks in euro-area sovereign yield curves", Document de travail n.352 Banque de France (2011).

51. Palladini, G, and R Portes, "Sovereign CDS and Bond Price Dynamics in the Eurozone", CEPR Discussion Paper 8651 (2011).

52. Pâris P., and Wyplosz C. , "To end the Eurozone crisis, bury the debt forever", voxEU, 6 August (2013).

53. Patel, S. and A. Sarkar, "Stock Market Crises in Developed and Emerging Markets", *Financial Analysts Journal*, 54(6) 50-59 (1998).

54. Rey, H., "Dilemma not Trilemma: The global financial cycle and monetary policy independence." Jackson Hole Economic Symposium. (2013).

55. Simsek, A., "Speculation and Risk Sharing with New Financial Assets", *The Quarterly Journal of Economics*, 128 (3): 1365-1396 (2013).

56. Stiglitz, J., "The Inefficiency of the Stock Market Equilibrium", *Review of Economic Studies*, 49(2), 241-261 (1982)

57. Tavakoli, J., *Structured finance and collateralized debt obligations: new developments in cash and synthetic securitization*, Wiley (2008).

58. Vause, N., "Enhanced BIS statistics on credit risk transfer", *BIS Quarterly Review*, December (2011).

59. Wyplosz, C. "Eurozone Crisis: It's About Demand, not Competitiveness." The Graduate Institute, Geneva (2013).

Table 1: Selection of the optimal linear model

	spec 1	spec 2	spec 3	spec 4	spec 5	spec 6	spec 7	spec 8
$Debt-to-GDP$	-0.127^{***}	-0.128^{***}	-0.165^{***}	-0.213^{***}	-0.128^{***}	-0.165^{***}	-0.089^{***}	-0.115^{***}
	(-7.83)	(-8.73)	(-11.19)	(-8.56)	(-8.11)	(-11.19)	(-5.62)	(-9.10)
$Debt-to-GDP^2$	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}
	(13.35)	(13.62)	(15.96)	(12.07)	(14.1)	(15.96)	(11.16)	(14.53)
Fiscal balance	0.025	0.025	0.007	0.113^{***}	0.051^{***}	0.007	0.07^{***}	0.056^{***}
	(1.35)	(1.35)	(0.38)	(3.88)	(2.73)	(0.38)	(3.91)	(3.06)
Unemployment	0.459^{***}	0.457^{***}	0.381^{***}	0.586^{***}	0.362^{***}	0.381^{***}	0.438^{***}	0.377^{***}
	(14.1)	(14.85)	(12.26)	(10.66)	(10.61)	(12.26)	(12.88)	(11.62)
Unit Labor Cost	-0.105^{***}	-0.104^{***}	-0.101^{***}	-	-	-0.101^{***}	-	-
	(-6.42)	(-6.56)	(-5.95)			(-5.95)		
Trade balance	-0.004	-	-	0.325^{***}	0.055	-	0.05	-
	(-0.10)			(5.38)	(1.35)		(1.31)	
Vix	0.033^{***}	0.033^{***}	0.034^{***}	0.021^{**}	0.016^{***}	0.034^{***}	0.014^{**}	0.016^{**}
	(5.22)	(5.24)	(5.14)	(2.2)	(2.56)	(5.14)	(2.35)	(2.55)
Bid-Ask	3.643^{***}	3.639^{***}	3.683^{***}	-	3.803^{***}	3.683^{***}	3.77^{***}	3.86^{***}
	(26.11)	(26.83)	(25.44)		(24.77)	(25.44)	(26.00)	(26.11)
Outstanding stock	-59.76^{***}	-59.70^{***}	$-$	-65.25^{***}	-	-	-58.16^{***}	-
	(-7.53)	(-7.53)		(-4.78)			(-6.98)	
Unconventional Monetary Policy	0.0032^{**}	0.0032^{**}	0.0068^{***}	0.0040^{*}	0.0055^{***}	0.0068^{***}	0.0018	0.0051^{***}
	(2.35)	(2.38)	(5.14)	(1.73)	(3.98)	(5.14)	(1.31)	(3.80)
AIC	0.197	0.197	0.329	1.284	0.409	0.329	0.294	0.414
Schwarz	0.207	0.207	0.339	1.294	0.419	0.339	0.304	0.424

Note: (*): significant at the 10% level; (**): significant at the 5% level and (***): significant at the 1% level.

Table 2: Linearity Tests wth a PSTR model

	H1: Fire-sale liquidation			H2: Feedback loop	Control
	Flight to liquidity	Flight to quality	Asymetry information		
AAA/ 10-year Treasury spread	111.4***				
10-year Swap spread	78.2***	78.2***			
A/ 10-year Treasury spread	84.8***	84.8***			
High-Yield bond/ Baa spread	70.8***	70.8***	70.8***		
StockbondsCorr		91.4***			
Cross-Section dispersion banks			51.2***		
IVOL bank				116.2***	
CmaxFin				194.2***	
Euribor-ois				119.4***	
CDS Snr-Fin				148.3***	
CDS Sub-Fin				130.9***	
I-traxx Europe					108.4***
X-over					91.9***
Hivol					79.0***
Vstoxx					64.2***
RVOL Germ					29,5***
RVOL Nonfin					41,4***
RVOL Pound					47,9***
RVOL Doll					36,6***
RVOL Yen					39.6***
FTSE 300					111.8***
S&P 350					111.6***
Domestic indices returns					37.7***

Notes: The corresponding LM statistic has an asymptotic $\chi^2(p)$ distribution under H_0. (*): significant at the 10% level; (**): significant at the 5% level and (***): significant at the 1% level.

Table 3: Estimation of the sovereign bond model with a PSTR model (Full Sample)

	Model 1	Model 2	Model 3
	Cmax Fin	CDS Snr-Fin	CDS Sub-Fi
Linearity Stat	194.2***	148.3***	130.9***
Smooth Parameter	111.4	0.266	0.090
Loc Parameter	0.819	239.7	391.6
RSS	175.7	218.5	247.9
Schwarz Crit.	-0.485	-0.267	-0.140

Notes: (*): significant at the 10% level; (**): significant at the 5% level and (***): significant at the 1% level.

Table 4: Estimation of the sovereign bond model with a PSTR model (two sub-samples)

	Model 1	Model 2	Model 3
	Cmax Fin	CDS Snr-Fin	CDS Sub-Fi
Sub-panel Italy, Spain and Portugal			
Linearity Stat	54.2***	88.2***	82.8***
Smooth Parameter	40.2	56.9	1.90
Loc Parameter	0.544	135.8	228.0
RSS	26.2	27.1	26.3
Schwarz Crit.	-1.68	-1.65	-1.68
Sub-panel Grece and Ireland			
Linearity Stat	42.0***	67.3***	61.9***
Smooth Parameter	140.8	0.62	7.55
Loc Parameter	0.863	155.2	261.7
RSS	75.1	115.7	110.5
Schwarz Crit.	-0.001	0.430	0.384

Notes: (*): significant at the 10% level; (**): significant at the 5% level and (***): significant at the 1% level.

Table 5: Estimates of the sovereign bond model with a PSTR model for Italy, Spain & Portugal

	Model 1		Model 2		Model 3	
	CDS Snr Fin		CDS Sub Fin		CMax Fi	
	β_1	β_2	β_1	β_2	β_1	β_2
Debt	0.0212^{***} (3.54)	0.035^{***} (4.28)	0.011^{*} (1.94)	0.042^{***} (5.23)	0.129^{***} (5.91)	-0.031^{***} (-3.48)
Squared Debt	-	-	-	-	-0.0004^{***} (-3.45)	0.0002^{***} (3.48)
Fiscal Balance	0.004 (0.30)	0.154^{**} (2.40)	0.053^{***} (3.43)	0.137^{**} (2.12)	-0.053^{*} (-1.80)	0.170^{***} (3.90)
Unemployment	0.015 (0.54)	0.112^{***} (2.70)	0.100^{***} (3.50)	0.116^{***} (2.65)	-0.155^{***} (-3.04)	0.179^{***} (4.62)
Unit Labor Cost	0.004 (0.48)	-0.024^{**} (-2.54)	-0.006 (-0.66)	-0.028^{***} (-2.89)	-	-
VIX	0.015^{***} (5.67)	0.035^{***} (4.71)	0.014^{***} (4.9)	0.038^{***} (5.27)	0.021^{***} (5.99)	0.002 (0.25)
Bid-Ask	15.18^{***} (12.9)	-10.44^{***} (-8.14)	43.05^{***} (6.16)	-38.33^{***} (-5.49)	7.71^{***} (10.66)	-2.51^{***} (-3.86)
Outstanding Stock of gov	-4.61 (-0.78)	-9.32^{***} (-5.70)	-11.67^{**} (-1.99)	-9.61^{***} (-6.57)	-	-
Unconv. Monet. Policy	0.0074^{***} (4.20)	0.0013 (0.57)	0.0072^{***} (5.79)	0.0003 (-0.15)	0.0071^{***} (7.34)	0.0019 (1.38)
Smooth Parameter γ	60.3		2.18		39.62	
Loc Parameter c	135.7		227.9		0.545	
Linearity Stat.	96.9^{***}		90.0^{***}		62.0^{***}	
RSS	27.6		26.81		26.4	
Schwarz Crit.	-1.685		-1.716		-1.786	

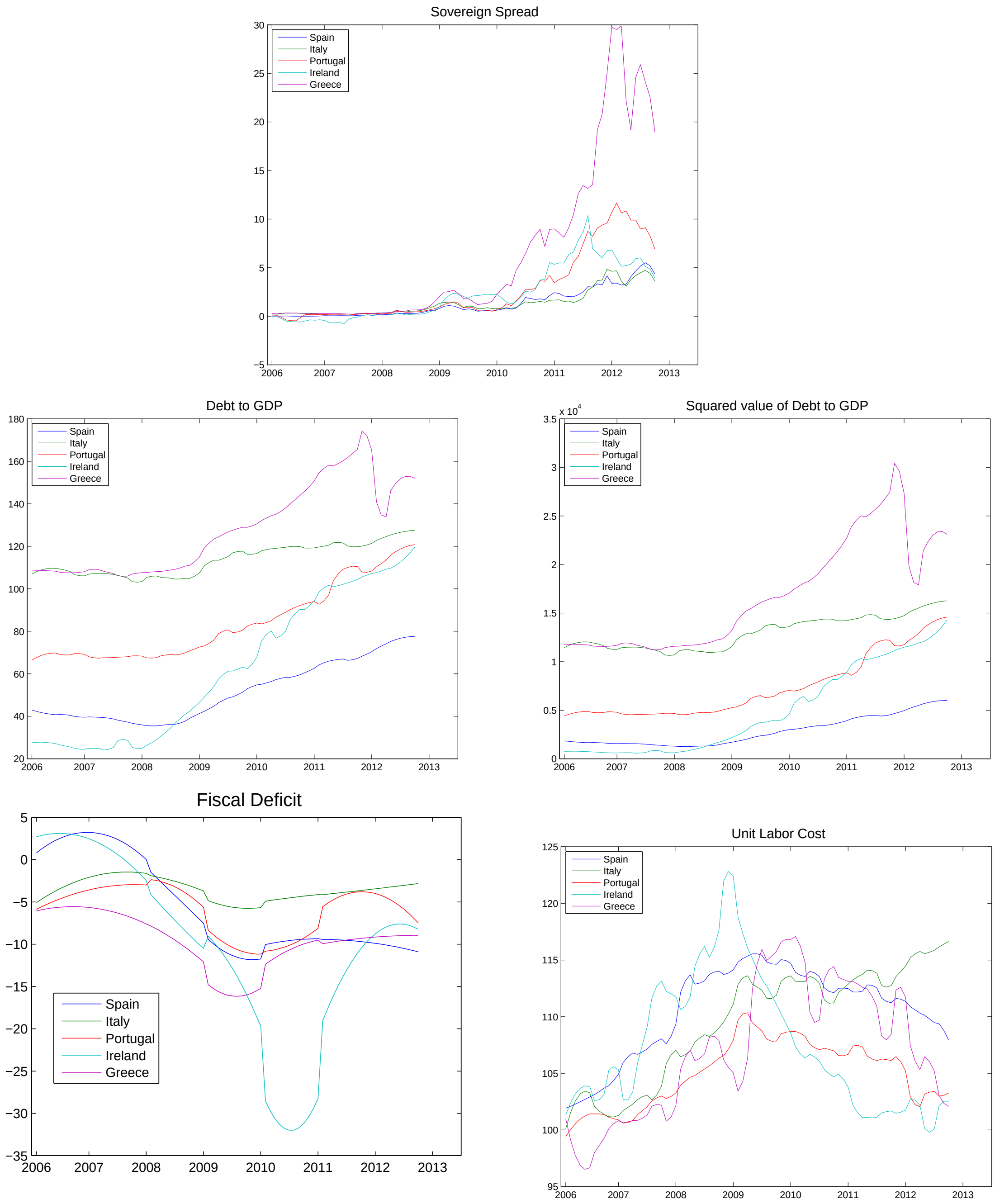
Notes: The T-stat in parentheses are corrected for heteroskedasticity. (*): significant at the 10% level; (**): significant at the 5% level and (***): significant at the 1% level.β_1 and β_2 correspond to the coefficient in Eq (11). β_1 is the coefficient in the first extreme regime . The coefficient in the second extreme regime is $\beta_1 + \beta_2$.

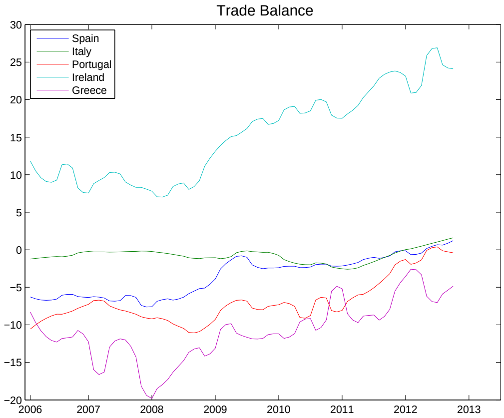
Table 6: Estimates of the sovereign bond model with a PSTR model for Greece & Ireland

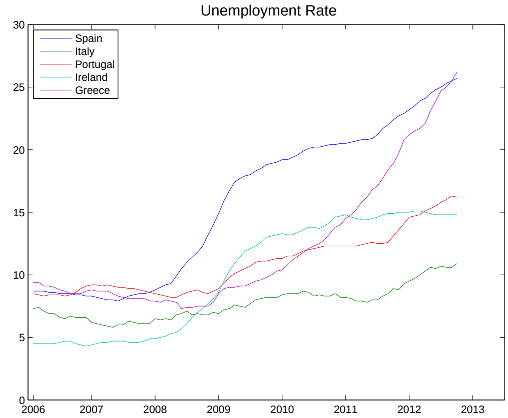
	Model 1		Model 2		Model 3	
	CDS Snr Fin		CDS Sub Fin		Cmax Fi	
	β_1	β_2	β_1	β_2	β_1	β_2
Debt	-0.101^{***} (-4.20)	0.086^{**} (2.13)	-0.114^{***} (-4.99)	0.067 (1.53)	-0.296^{***} (-9.28)	0.242^{***} (4.05)
Squared Debt	0.0005^{***} (4.89)	-0.0004^{*} (-1.82)	0.001^{***} (6.50)	0.000 (-1.49)	0.001^{***} (10.89)	0.000 (-0.48)
Fiscal Balance	0.057^{***} (2.63)	0.031 (0.65)	0.056^{***} (2.91)	-0.047 (-0.81)	-0.092^{***} (-2.61)	0.109^{**} (2.28)
Unemployment	0.57^{***} (8.98)	0.69^{***} (4.30)	0.602^{***} (9.48)	0.639^{***} (3.99)	0.849^{***} (7.85)	0.020 (0.10)
Unit Labor Cost	0.03^{*} (1.73)	-0.008^{***} (-4.13)	0.022 (1.45)	-0.082^{***} (-4.02)	-0.036^{**} (-2.05)	-0.048^{**} (-2.10)
VIX	0.03^{***} (3.84)	-0.0135 (-0.44)	0.033^{***} (4.53)	-0.007 (-0.23)	0.025^{***} (3.99)	0.019 (0.83)
Bid-Ask	4.55^{***} (3.5)	-1.7 (-1.27)	4.735^{***} (4.19)	-1.904 (-1.61)	2.67^{***} (6.97)	1.175^{**} (2.05)
Outstanding Stock of gov	-	-	-	-	$161.9 * **$ (3.31)	-632.3^{***} (-5.96)
Uncon. Monet. Policy	0.026^{***} (6.26)	-0.038^{***} (-5.48)	0.024^{***} (6.49)	-0.033^{***} (-4.49)	0.0275^{***} (7.20)	-0.0459^{***} (-7.20)
Smooth Parameter γ	0.43		6.57		140.8	
Loc Parameter c	154.8		262.0		0.863	
Linearity Stat.	63.4***		60.2***		42.0***	
RSS	116.3		111.1		75.1	
Schwarz Crit.	0.358		0.312		-0.001	

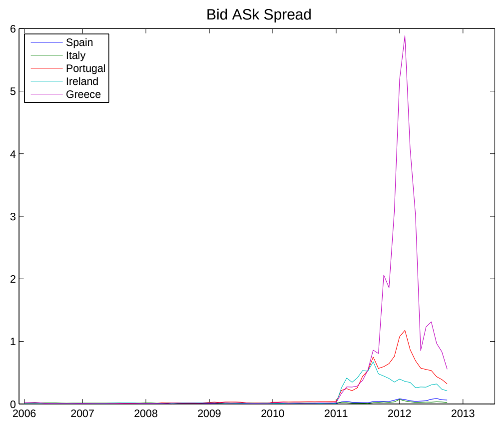
Notes: The T-stat in parentheses are corrected for heteroskedasticity. (*): significant at the 10% level; (**): significant at the 5% level and (***): significant at the 1% level.β_1 and β_2 correspond to the coefficient in Eq (11). β_1 is the coefficient in the first extreme regime . The coefficient in the second extreme regime is $\beta_1 + \beta_2$.

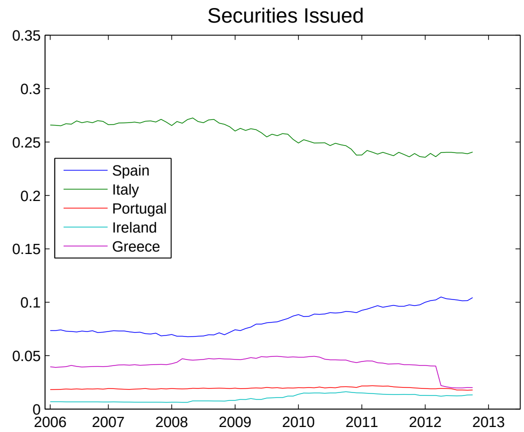
Figure 1: Dependent and Explanatory Variables

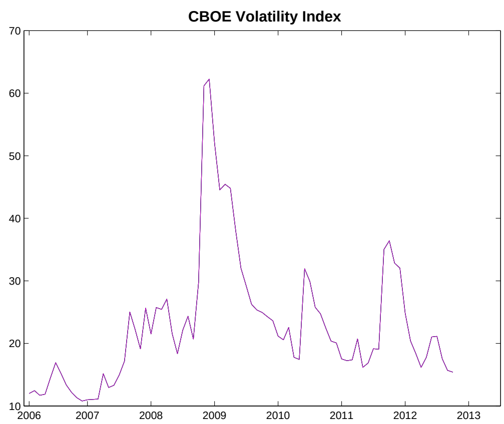



Trade Balance
Spain
Italy
Portugal
Ireland
Greece
30
25
20
15
10
5
0
−5
−10
−15
−20
2006
2007
2008
2009
2010
2011
2012
2013


Unemployment Rate
Spain
Italy
Portugal
Ireland
Greece
30
25
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013


Bid ASk Spread
Spain
Italy
Portugal
Ireland
Greece
6
5
4
3
2
1
0
2006
2007
2008
2009
2010
2011
2012
2013


Securities Issued
Spain
Italy
Portugal
Ireland
Greece
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2006
2007
2008
2009
2010
2011
2012
2013


CBOE Volatility Index
70
60
50
40
30
20
10
2006
2007
2008
2009
2010
2011
2012
2013

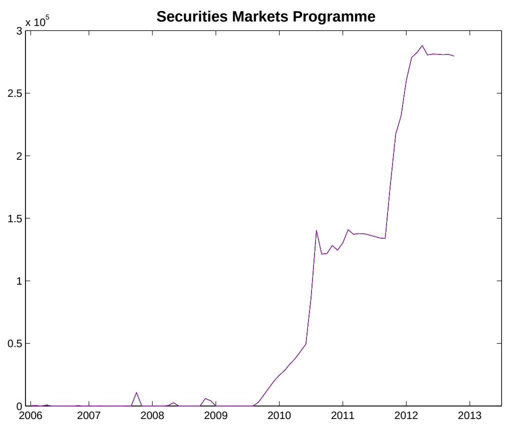
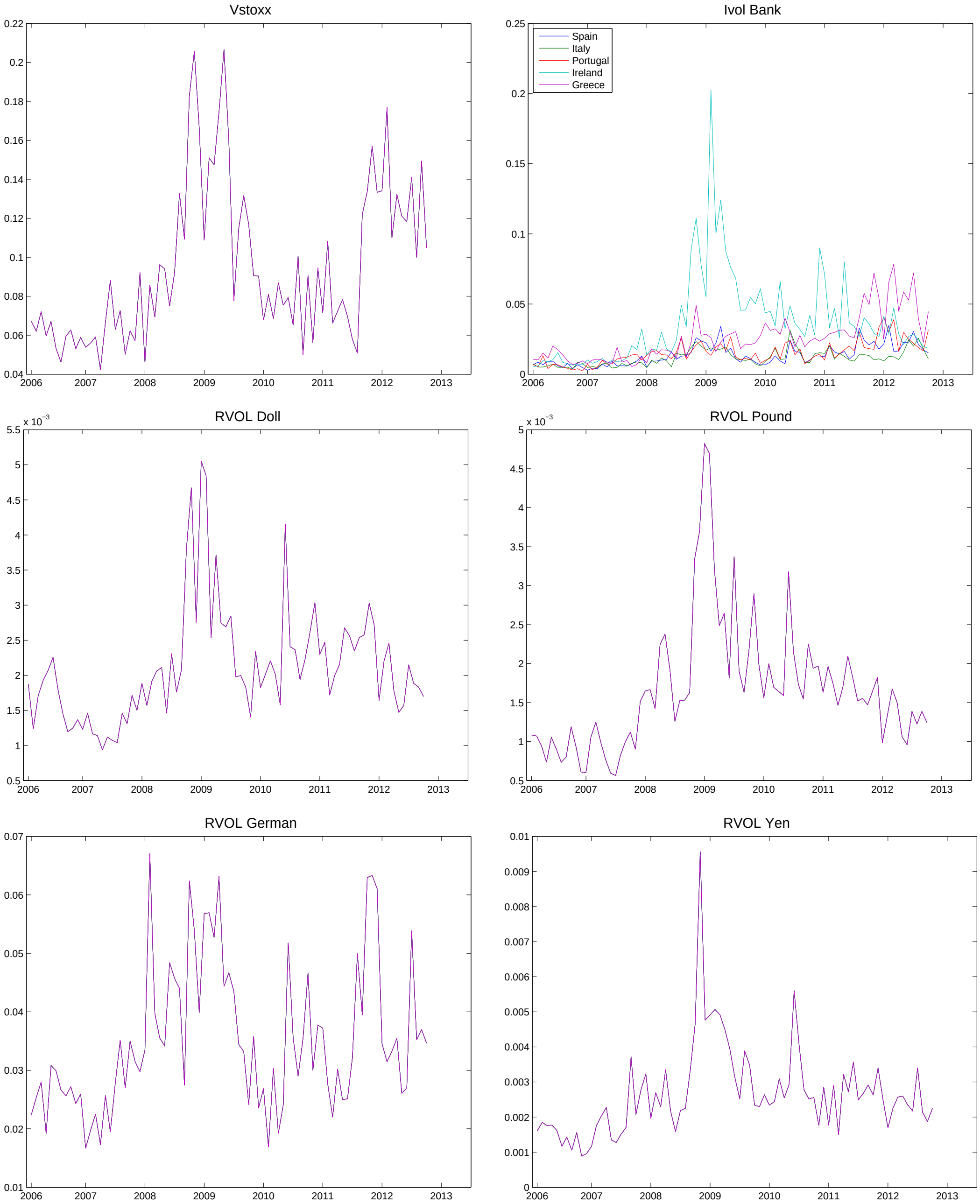
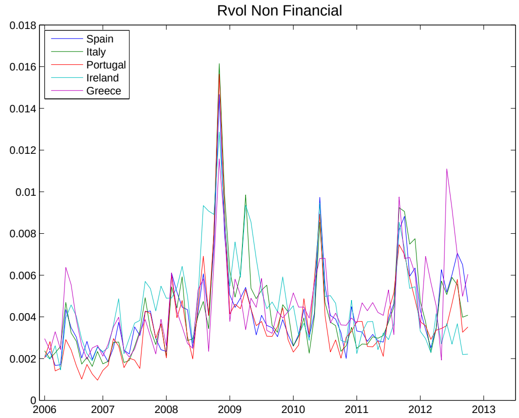
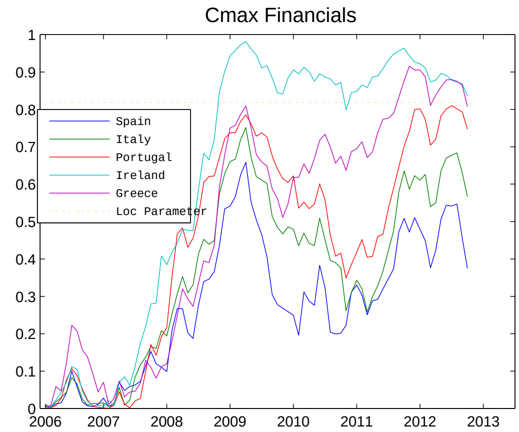
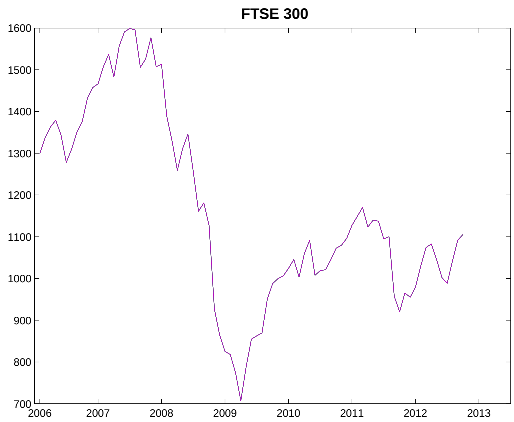

Securities Markets Programme
x 10^5
3
2.5
2
1.5
1
0.5
0
2006
2007
2008
2009
2010
2011
2012
2013

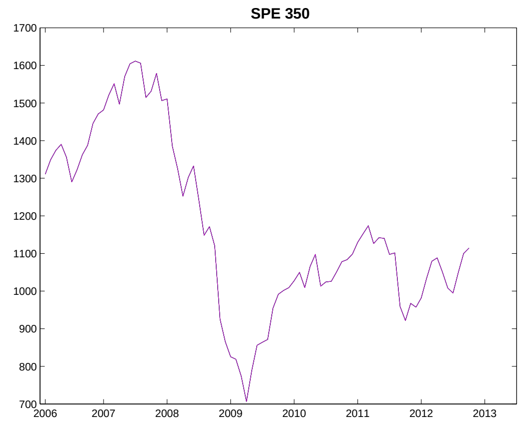
Figure 2: Threshold Variables

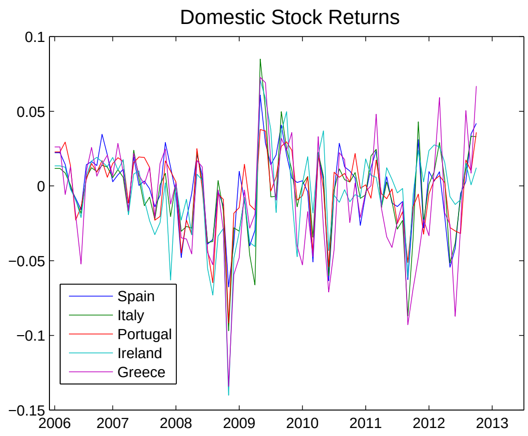

Vstoxx
Ivol Bank
Spain
Italy
Portugal
Ireland
Greece
RVOL Doll
RVOL Pound
RVOL German
RVOL Yen
2006
2007
2008
2009
2010
2011
2012
2013

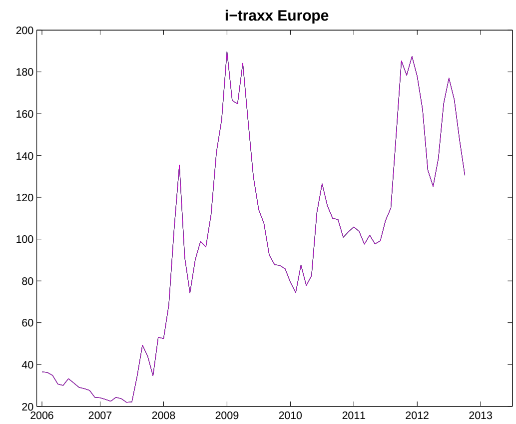

Rvol Non Financial
Spain
Italy
Portugal
Ireland
Greece


Cmax Financials
Spain
Italy
Portugal
Ireland
Greece
Loc Parameter


FTSE 300


SPE 350


Domestic Stock Returns
Spain
Italy
Portugal
Ireland
Greece


i−traxx Europe

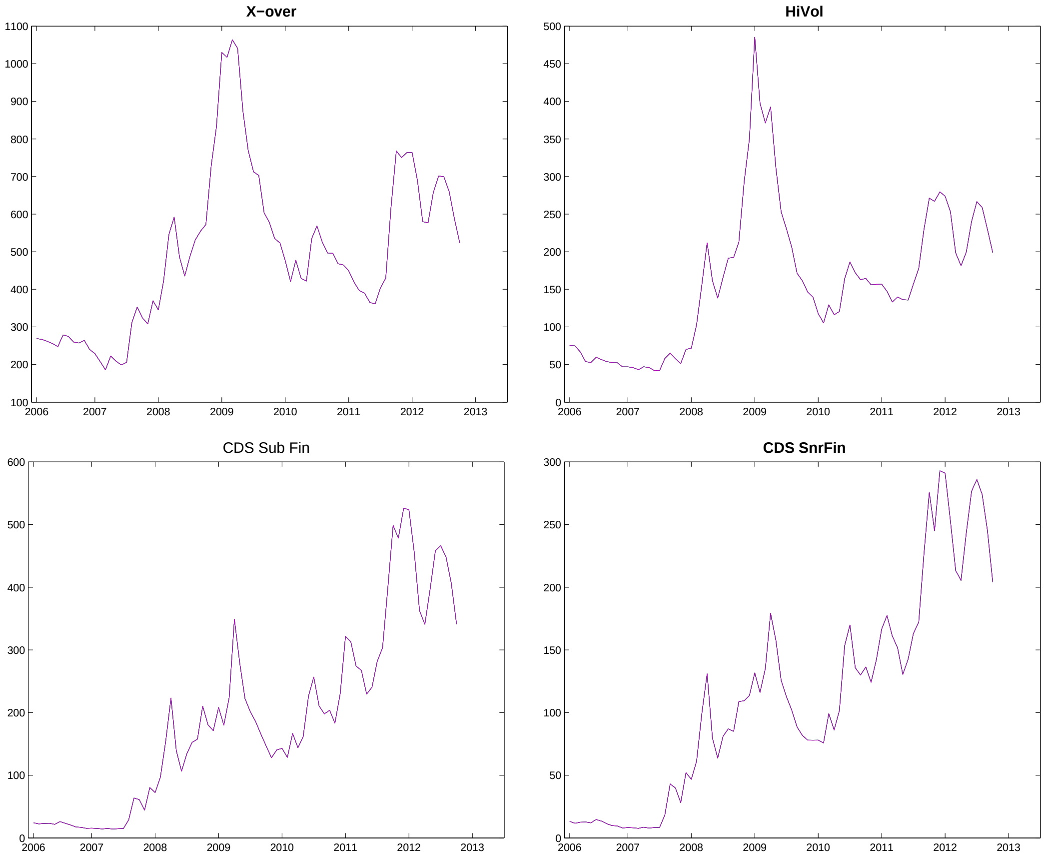
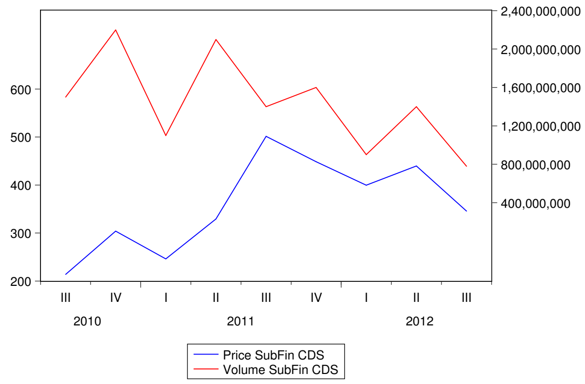
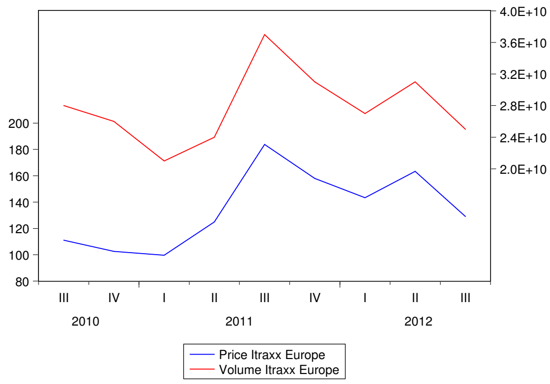

X−over
HiVol
CDS Sub Fin
CDS SnrFin
2006
2007
2008
2009
2010
2011
2012
2013

Figure 3: I-Traxx CDS Indices, Volume and Prices





Notes: Source: DTCC. Lh scale : prices in basis points. Rh scale: volumes in US$