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The impact of unconventional monetary policy on the sovereign bank nexus within and across EU countries. A time-varying conditional correlation analysis

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Abstract

We investigate the time varying dynamics of the linkages between sovereign and bank default risks over the period 2006-2015, using the credit default swap (CDS) spreads of the bonds of major international banks and of sovereign issuers as indicators of risk within four major European countries. The nexus between bank risk in core countries and sovereign risk of peripheral countries is also analyzed, under the hypothesis that higher bond yields and preferential treatment of bond issued by euro sovereigns under Basle II may have favored the stocking of peripheral sovereign bonds in core bank portfolios. The use of a time-varying regime switching correlation analysis, the STCC-GARCH, allows to identify the economic variable behind the state shifts, the so-called "transition variable", and to date precisely the changes in the size of the correlations that are due to shocks (viz. the Lehman crisis, the evolution of the Greek crisis) or to unconventional monetary policies such as Quantitative Easing and TLTRO.

Jel Classification E43, E52, F36, C32

Keywords CDS spreads, Unconventional monetary policy, STCC-GARCH correlation analysis

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1. Introduction

The financial crisis of 2007 triggered a series of spillover effects between the banking and the sovereign sectors both within countries and across borders. In this context, the word nexus has often been used to define the link between the default risk of sovereign and the default risk of banks or, in some cases, the reverse. Given the critical implications of these phenomena, the comprehension of how sectorial conditions are transmitted and of how sovereign and bank risk feedback loops operate is of paramount importance for both policymakers and regulators.

In this paper we document the time varying dynamics of the linkages between sovereign and bank default risks over the period 2006-2015. We use the credit default swap (CDS) spreads of the bonds of major international banks and of sovereign issuers as indicators of bank and sovereign default risk respectively.[1]

Several papers provide evidence and explanation of the different channels through which bank risk may impinge on sovereign risk and vice versa. Recently Acharya et al. (2015), De Bruyckere et al. (2013) and Brunnermeier et al. (2016) analyze theoretically and empirically the feedback loops between sovereign risk and bank risk considering both domestic and non-domestic counterparties. The direction of causality can run from bank to sovereign risk in countries with sound public finances where taxpayers may be asked to back up banks in distress, or the other way around, i.e. from sovereign to banks when a fragile public sector may affect both asset and liability sides of banks' balance sheets. Whatever the cause and the direction of the spillover there are factors that tend to bolster the feedback loop. In order to break this loop and to reduce the degree of correlation we must understand the structure and the dynamics of these linkages.

Angelini et al. (2014) assess the impact of sovereign risk on bank risk and investigate the interconnections between sovereigns and banks by

[1] CDS are swap agreements that represent insurance contracts in which the protection buyer pays a regular insurance premium, the CDS spread, which is typically denoted in annualized basis points of the insured notional. If a credit event occurs, i.e. a sovereign or a bank default, the protection buyer is entitled to receive compensation for the incurred loss from the protection seller.

measuring the size of assets and liabilities in a bank balance sheet. Gennaioli et al. (2014) offer theoretical and empirical evidence of the transmission of a sovereign debt crisis to the banking system and to the real economy via the banks' holdings of sovereign debt (assets side). An increase or a decrease in the fragility of the sovereign sector may affect its creditworthiness. This alters both the market price of the public debt - causing either a loss or a gain in the banks' portfolio of sovereign securities - and the value of banks' credit portfolios, depending on their exposure to government loans. The overall effect depends on the degree of portfolio diversification since home biases strengthen the "within country" nexus. This phenomenon might also be enhanced by the current regulation which gives a preferential treatment to public securities in terms either of reduced risk weights and concentration limits, or of their use for collateral purposes. As for liabilities, in response to the 2008 financial crisis, several governments provided explicit guarantees to bank bond issuers as a means to restore the functioning of the wholesale funding market. If a negative shock, such as a sovereign downgrade, reduces the value of the guarantees then funding will be more costly (Panetta, 2011). This increase will be passed on to the yield curve with effects on credit availability and on economic growth, determining spillovers on credit quality and thus on the default probability of banks. Furthermore the sovereign rating is a ceiling for private issuers. Hence a sovereign downgrade affects the funding market also by directly increasing the cost of funding of the issuer or reducing the available liquidity. Finally, as seen in 2008, financial distress may transfer to the sovereign when a government is asked to finance the bailout of troubled banks. The rescue measures may well increase the fiscal burden above or near sustainability level.

Apart from the domestic sectorial nexus, recent evidence points to the impact of cross-border linkages in transmitting national banking distress. Shocks could occur between bank risks across different countries due to counterparty risk and to information contagion (Lang and Stulz, 1992, Jorion and Zhang, 2007, 2009). Alternatively there could be interdependence between sovereign risks across different countries due to information contagion and/or explicit/implicit guarantees (see Lucas et al., 2014, Benzoni et al., 2015, Augustin et al., 2016, Kallestrup et al., 2016).

We also consider a third kind of cross border contagion, characterized by a sharp increase in the interdependence or co-movement between financial sectors of differing countries (e.g. linkages between sovereign risk in one country and bank risk in an another country). This kind of contagion could be triggered by the likelihood of insolvency of sovereigns if their obligations constitute a significant share of foreign bank portfolios. The spillover can be due to foreign borrowing or lending exposures in the banking sector and be triggered either by systemic or by idiosyncratic factors (see Tonzer, 2015, and Ballester et al., 2016). Kallestrup et al. (2016) show that the size and riskiness of foreign asset holdings of the largest banks are an important determinant, not only of their own CDS premiums, but also of the CDS premiums of the sovereign in which the banks reside. Breckenfelder and Schwaab (2015) analyze risk contagion from the banking to the sovereign sectors across borders of the euro area on the basis of the results of the Comprehensive Assessment 2014 (CA 2014). They find that changes in CDS spreads in "non-stressed" countries become more sensitive (during crises) to the equity values of banks located in "stressed" countries. Thus, there is a risk perception connectedness in the Euro area through which bank risk shocks in one country can affect the credit risk of other sovereigns. From an empirical point of view, analyses of the nexus based on standard econometric models, which assume a priori causality hypotheses, may be distorted during financial upheavals since the very direction of causality is likely to change. We preferred, therefore, to avoid a priori commitments and base our analysis on correlations. However, as is well known from the literature on financial contagion (see Forbes and Rigobon, 2002, among many others) unconditional correlation analysis is distorted in the presence of volatility shifts.

Our empirical analysis is based on an accurate investigation of the dynamics of conditional correlations. The standard Constant Conditional Correlation GARCH (CCC-GARCH) procedure of Bollerslev (1990) is too restrictive and may provide biased estimates in the periods of severe financial disruption analyzed in this paper. We decided to discard it. Interesting improvements can be found in Tse and Tsui (2002) and in Engle (2002), where the conditional correlation itself is assumed to be time-varying. These studies, however, do not account for the regime shifts that constitute a stylized aspect of the recent financial contagion events. In this paper conditional correlations are parameterized with the help of a regime switching model, the Smooth Transmission Constant Correlation GARCH (STCC-GARCH) set out by Berben and Jansen (2005) and Silvennoinen and Teräsvirta (2005, 2007). This procedure is used to investigate the time-varying and regime-switching behavior of the conditional correlations between European bank and sovereign bond CDS daily rates of change over the 2006-2015 time interval.

Our contribution to the literature is threefold. Firstly, focusing on correlations we abstract from the causality direction (which is both empirically and theoretically mostly bidirectional). Secondly, we add to the extant literature of cross border linkages by analyzing the nexus between bank risk in core countries and sovereign risk of peripheral countries under the hypothesis that higher bond yields and preferential treatment of bond issued by euro sovereigns under Basle II could have favored the stocking of peripheral sovereign bonds in core bank portfolios. Thirdly, we implement a state of the art time-varying regime switching correlation analysis, the STCC-GARCH, that allows both to identify the economic variable behind the state shifts, the so-called "transition variable", and to date precisely the changes in the size of the correlations that are due to shocks (viz. the Lehman crisis, the evolution of the Greek crisis, the CA 2014 announcements) or to unconventional policy actions such as the Quantitative Easing and the TLTRO. The effect of the latter on the strength of the nexus is implicitly a way of gauging the effectiveness of the specific instrument.

The remainder of the paper proceeds as follows. In Section 2 we explain our empirical methodology based on the smooth transition conditional correlations approach. Section 3 presents an overview of the data. This is followed in Section 4 by a discussion of the main results of the within country analysis. Cross country evidence on the nexus can be found in Section 5 and Section 6 concludes the paper.

2. The STCC-GARCH parameterization of time-varying correlations

Consider a *Nx1* vector y_t of CDS daily rates of change, with the following conditional mean dynamics

$$y_t = \mu + A(L)y_t + u_t, \qquad t = 1,\ldots,T \tag{1}$$

where *A(L)* is an autoregressive *NxN* polynomial lag matrix, *μ* a *Nx1* vector of constants and u_t a *Nx1* vector of residuals such that

$$u_t | \Psi_{t-1} \sim iid(0, H_t) \tag{2}$$

where Ψ_{t-1} is the relevant information set.

The conditional variance matrix of the residuals has the following time-varying structure

$$H_t = E(u_t u_t' | \Psi_{t-1}) \tag{3}$$

Bollerslev (1990) posits in the CCC-GARCH parameterization that the conditional variance of each residual time series $u_{it}, i = 1, \ldots, N$, follows a GARCH(1,1) process and that the correlations are constant. The conditional second moments are thus modeled as

$$h_{iit} = \omega_i + \alpha_i u_{it-1}^2 + \beta_i h_{iit-1}, \quad i = 1, \ldots, N \tag{4}$$

$$h_{ijt} = \rho_{ij}(h_{iit}, h_{jjt})^{0.5}, \qquad 1 \le i < j \le N \tag{5}$$

Denoting D_t as a *NxN* diagonal matrix with diagonal elements given by $(h_{iit})^{0.5}$ and Γ as a constant *NxN* correlation matrix, the conditional covariance matrix reads as

$$H_{t=}D_t \Gamma D_t \quad (6)$$

Berben and Jansen (2005) and Silvennoinen and Teräsvirta (2005) generalize the CCC-GARCH model and allow for smoothly time-varying conditional correlations. The latter are assumed to switch over time from one (extreme) constant correlation regime to the other, according to the distance from a threshold value of an ad hoc transition variable. The dynamics of the shifts are driven by a continuous logistic function.

The time t *NxN* conditional correlation matrix P_t can be written as

$$P_t = (1 - G_t)P_1 + G_t P_2 \quad (7)$$

Where P_1 and P_2 are assumed to be constant *NxN* positive definite correlation matrices. The logistic function G_t is defined as

$$G_t(x_t; \gamma, c) = \frac{1}{1+exp\{-\gamma(x_{t-d} - c)\}}, \quad \gamma > 0 \quad (8)$$

x_{t-d} is the transition variable with delay *d* and the coefficient γ and the threshold *c* determine, respectively, the speed of adjustment and the location of the transition between the two regimes. P_t is a mixture of the two correlation matrices P_1 and P_2. When $(x_{t-d} - c)$ is large and positive, G_t is close to 1 and P_t nears P_2, and when $(x_{t-d} - c)$ is large and negative, G_t is close to 0, and P_t nears P_1.[2]

In order to justify the use of a nonlinear time-varying parameter model of this kind, we implement, among others, the Lagrange Multiplier test set out by Tse (2000) and Silvennoinen and Teräsvirta (2005), extending the Taylor-expansion procedure originally set out in Luukkonen et al. (1988). Under the null hypothesis $H_0: \gamma = 0$, the STCC-GARCH model collapses to a constant correlation (CCC-GARCH) model, whereas the alternative H_1 is compatible with a STCC-GARCH time–varying conditional correlation parameterization. In order to avoid the difficulties due to the non-identification of the nuisance parameters under the null, the logistic transition function of the STCC-GARCH is replaced by a first order Taylor

[2] If γ → ∞ G_t becomes a step function. $P_t = P_2$ if $(x_{t-d} - c) > 0$, and $P_t = P_1$ if $(x_{t-d} - c) < 0$.

approximation about $\gamma = 0$. An auxiliary STCC-GARCH model is obtained in which the time-varying correlation matrix can be linearized as follows

$$P_t^* = P_1^* - x_{t-d} P_2^* \quad (9)$$

where

$$P_1^* = \frac{1}{2}(P_1 + P_2) + \frac{1}{4}c(P_1 - P_2)\gamma \quad (10)$$

$$P_2^* = \frac{1}{4}(P_1 - P_2)\gamma \quad (10')$$

When $\gamma = 0$, $P_2^* = 0$ and the CCC-GARCH model holds. This null hypothesis can be tested using the LM-test set out in Silvennoinen and Teräsvirta, (2005, equation 10, page 8), asymptotically distributed as a χ^2 with $N(N-1)/2$ degrees of freedom.[3]

3. The data

To identify the effects of unconventional monetary policy on the sovereign-bank nexus we build a data set of daily market observations on sovereign and bank CDS 5 years spreads and on other financial market indicators, such as the VIX index and the Greek 10 years sovereign bond yield spread vs the German 10 years bund, quoted by Bloomberg and the Chicago Board Options Exchange (CBOE). Following Alter and Schüler (2012) and Black et al. (2013), among others, we use the CDS 5 years premia as measure of sovereign and bank default risks. Table A.1 contains an overview of the definitions as well as the summary statistics of the daily rates of change of bank and sovereign 5 year CDS premia (respectively $Dcdsb_t$ and $Dcdss_t$), of the daily change of the VIX (ΔVIX_t) and

[3] The STCC-GARCH model is typically discussed using parameterizations in which the conditional mean equations are martingales. However, as pointed out by Tse (2000, page 114), if the unknown means are linear in the parameters, the asymptotic variance matrix of the MLE is block diagonal with respect to the conditional mean and conditional variance parameters and the LM nonlinearity test above, computed using only the conditional variance parameters, is asymptotically valid.

of the spread of the Greek 10 years government yield vs the yield of German 10 years bund ($\Delta GGsp_t$).[4]

Our panel consists of four European countries: France, Germany, Italy and Spain. The data set spans the period from 9 January 2006 to 6 June 2015 and encompasses both the 2007-2008 crisis and the European debt crisis. Unfortunately, data availability problems prevent us from looking into a longer pre-crisis period. The sample includes CDS spreads on 5 years sovereign bonds of two core countries (France and Germany) and of two countries from the periphery (Italy and Spain). The largest countries, considering output, of the EMU, they differ significantly in terms of debt to GDP ratios, of risk profiles and ratings.[5] As for the banking sector, we construct for each country a domestic bank CDS 5 years premium by taking the average of the 5 years CDS spreads on bonds issued by the three major national banks, according to the availability of the time series.[6]

The link between bank and sovereign sectors could run both ways. Negative shocks to the banking sector (i.e. an increase of its default risk) could affect the default probability of the sovereign if the latter is expected to provide guarantees and financial aid to banks. Negative shocks to the sovereign debt sustainability could affect the asset value of banks according to the composition of their portfolios. Indeed, the sovereign bank nexus is strictly associated to the exposure of domestic bank portfolios to the domestic public debt, a portfolio structure frequently chosen before the inception of the European crises and, in some cases, even after. In table A.2 the Granger causality tests indicate that the causality between domestic banks and domestic sovereign runs both ways for France, Italy and Spain while it goes one way (from banks to sovereign) for Germany. Not a surprising result as Italian, Spanish and

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[4] Throughout the paper Dx_t is assumed to be the rate of change of the variable x_t and Δx_t is assumed to be its change (first difference).

[5] Overall, the selected countries account for 76% of the GDP of the EMU. As for the net debt to GDP ratio, in 2015 Italy has the largest one (113%) after Greece. The remaining countries follow with 89% (France), 65% (Spain) and 48% (Germany). (Source IMF WEO October 2015 data base.)

[6] The selected banks are Société Générale, BNP Paribas and Crédit Agricole in the case of France; Commerzbank, Deutche Bank and ING (the Netherlands), in the case of Germany; Intesa Sanpaolo, Unicredit and MPS for Italy and finally Santander, BBVA and Caixa for Spain. The data source is Bloomberg.

French banks were more exposed to domestic risky assets whereas German bunds were considered a safe haven. This picture is coherent with data computed by other researchers. Beltratti and Stulz (2015) find that the Italian and Spanish banks hold large amounts of bonds issued by their national governments, up to 169% and 125%, respectively, of their tangible equity, well above the percentage of domestic bond owned on average by core countries (33%).[7]

Figure 1 shows that, within each country, bank and sovereign CDS tend to co-move tightly, with an average moving correlation of around 40%.

These correlations display common features across the selected countries. Firstly, they are quite volatile and shift, in a period of a few months around the Lehman crisis, from values close to zero to values as high as 0.75. Secondly, a cursory visual inspection of these patterns would suggest that there is no clear structural shift corresponding to the onset of the sovereign debt crisis (originated in Greece in 2010) or to its peak in the Summer of 2011. Germany and France, on one side, and Italy and Spain, on the other, seem to have been influenced by common drivers.

<Insert Figure 1 about here>

The pairwise correlation analysis of Table A.3 shows that the sovereign bank risk nexus significantly increases during crises and decreases after September 2012, when the ECB announced a new bond buying plan. In the case of Spain - the only exception to this pattern - a possible explanation, set out by Angelini et al. (2014), is that the turmoil originated in the banking and not in the sovereign sector, reducing in this way the impact of the unconventional monetary tools.[8]

Moreover, the exposure of the EU banking sectors to highly indebted peripheral sovereign countries could also be a powerful mean to transmit turbulences across countries, according to the nexus paradigm. Using BIS

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[7] See Beltratti and Stultz (2015, table 1, page 27).

[8] The Spanish sovereign bank nexus behaves differently also in other empirical studies. Stanga (2014) finds, using a structural VAR, that bail-out shocks and sovereign shocks affect Spanish banks CDS permanently, whereas the effects are temporary in the case of Italy, France and Germany.

data, Korte and Steffen (2015) find that the banking sector non-domestic exposure to all EU sovereign bonds in terms of GDP is rather homogeneous across countries, 5.4% and 6.6%, for Italy and Spain, and 5.3% and 11.7%, respectively, for Germany and France. Not so for the non-domestic exposure to peripheral EU sovereign bonds in terms of GDP, which is low for Italy and Spain (0.3% and 1.1% respectively), and much higher in France (4%) and in Germany (2.3%).[9]

These results suggest that the banking sector holdings of government bonds across the EU countries are important. This portfolio structure may have potential relevant consequences on the CDS correlations analyzed in this paper.

4. Sovereign - bank nexus: within country analysis

The previous analysis suggests that in our data set the unconditional correlations between the daily rates of change of bank and sovereign bond CDS premia tend to vary over time.

The properties of these shifts are investigated here with the help of a sophisticated time-varying conditional correlation procedure. As usual, we show that the selection of the latter is justified by the data. Two preliminary tests for the adequacy of the constant correlation GARCH are performed, tests originally set out by Bollerslev (1990, page 502) in a bivariate context. As pointed out by Aslanidis et al. (2010), they are appropriate for testing against the DCC-GARCH alternative of Engle (2002) and of Tse and Tsui (2002). The LM test of Tse (2000) and of Silvennoinen and Teräsvirta (2005), discussed in a previous section, is also implemented, where the alternative hypothesis is provided by a STCC-GARCH. The findings, set out in Table 1, suggest that the null of a CCC-GARCH is mostly rejected when the alternative model is parameterized as a DCC-GARCH and overwhelmingly rejected when the alternative is assumed to be a STCC-GARCH.

<Insert Table 1 about here >

[9] See Korte and Steffen (2015, table 3, panel A and B, page 39).

As a consequence the model selected to analyze the dynamics of the conditional correlations between the daily rates of change of the CDS premia on banks and on sovereign bonds is of the STCC-GARCH variety and is parameterized by the following mean and variance conditional equations:

$$Dcdss_t = a_{01} + \sum_{z=1}^{l} a_{z1}\, Dcdss_{t-z} + u_{1t}$$
$$Dcdsb_t = a_{02} + \sum_{z=1}^{h} a_{z2}\, Dcdsb_{t-z} + u_{2t} \qquad (1')$$

$$h_{iit} = \omega_i + \alpha_i u_{it-1}^2 + \beta_i h_{iit-1}, \quad i = 1, 2 \qquad (4')$$

$$h_{ijt} = \rho_{ij}(h_{iit}\, , h_{jjt}\,)^{0.5}, \qquad 1 \le i < j \le 2 \qquad (5')$$

where, as in equation (6) above

$$\begin{bmatrix} h_{11t} & h_{12t} \\ h_{21t} & h_{22t} \end{bmatrix} = \begin{bmatrix} h_{11t}^{0.5} & 0 \\ 0 & h_{22t}^{0.5} \end{bmatrix} \begin{bmatrix} 1 & \rho_{12t} \\ \rho_{21t} & 1 \end{bmatrix} \begin{bmatrix} h_{11t}^{0.5} & 0 \\ 0 & h_{22t}^{0.5} \end{bmatrix} \qquad (6')$$

and

$$\rho_{ijt} = (1 - G_t)\rho_{ij}^1 + G_t \rho_{ij}^2 , \qquad 1 \le i < j \le 2 \qquad (7')$$

G_t being parameterized by the logistic function (8).[10]
For each country we tested four transition variables (x_t) which are likely to trigger a regime shift. These are $\Delta \mathrm{GGsp_t}$, the daily change in the spread between the Greek and the German 10 year sovereign bond yield, $\Delta \mathrm{VIX_t}$, the daily change of the VIX index, $\Delta \mathrm{cdss_t^+}$, the positive daily change in the sovereign CDS, $\Delta \mathrm{cdsb_t^+}$, the positive daily change in the bank CDS. The selection of the proper transition variable and of the associated delay lag d is based on the quality of the estimation fit. In the case of Germany and France the transition variable is the daily change in the spread between

[10] The order of the conditional mean autoregressions is low. $h = 1$ throughout and $l = 1$ for Spain and Italy, and is equal to 2 and 3 in the case, respectively, of France and of Germany.

the Greek and the German 10 year sovereign bond yields $\Delta \mathrm{GGsp_t}$, with a lag of 3 and 6 working days, respectively; for Italy the transition variable is the positive daily change in the sovereign CDS, $\Delta \mathrm{cdss}_t^+$ with a one day delay; for Spain, in line with the hypothesis that the origin of the crisis is to be ascribed to the fragility of its banking system, the trigger is the positive daily change in the bank CDS, $\Delta \mathrm{cdsb}_t^+$, with a lag of 5 working days.

The conditional correlations and the smooth transition parameters are to be found in Table 2. Strongly significant from a statistical point of view, they have the appropriate size and the expected sign.[11] Tests on the standardized residuals, obtained using the triangular conditional variance parameterization, fail to detect serial correlation or conditional heteroskedasticity and suggest that the quality of the fit is highly satisfactory. However, since the Jarque-Bera statistics systematically reject the null of normality, the estimates are obtained using the robust QMLE procedure developed by Bollerslev and Wooldridge (1992).

< Insert Table 2 about here >

The size of the conditional correlation coefficients (ρ_{12}^1 and ρ_{12}^2) is from two to three times larger in the second than in the first regime, with the notable exception of Germany, where the increase is smaller. In the second regime, the transition variable exceeds the estimated threshold value appearing in the logistic model and thus $x_t - c$ is positive, whereas in the first regime $x_t - c$ is negative.

The speed of adjustment to the shift of the selected transition variable ($\Delta GGsp_t$) is much higher in France and Germany than in the peripheral countries. It reflects a rise in the risk perception, associated to the domestic banking sector, due to the vagaries of the Greek crisis. Bouts of high correlation correspond to a worsening of the crisis, especially towards the end of the sample when renewed domestic instability, followed by the

[11] The full set of mean and variance equations parameters of the GARCH estimates are not reported here for the sake of parsimony and are available from the authors upon request.

government's resignation, brought about the electoral victory of left wing parties highly critical of the Troika agreements.

As mentioned above, the Italian and the Spanish correlations react to different transition variables, signifying a different origin of the financial stress, rooted in the national sovereign and banking sectors, respectively. Overall, the delay parameters vary between 1 and 6 working days, a sign of the quick change in bank risk perception by financial participants. Here too the shifts of the correlations parameters are related to those of their specific transition variables and can be easily associated to the events listed in the Appendix. An inspection of the graphs of Figure 2 allows to detect some interesting patterns.

<Insert Figure 2 about here>

The impact of the Lehman crisis on the sovereign bank nexus is neat in all the countries of the sample, with the exception of Spain, where there is clear evidence of additional preexisting domestic banking fragility problems due to the build-up and subsequent bursting of a housing bubble. After March 2009, following the ECB programme of "enhanced credit support" and the introduction of Quantitative Easing in the UK, the CDS within country connectedness is strongly reduced in Germany, France and Italy and, to a lesser extent, in Spain.

In October 2010, the warning by the ECB council regarding the Greek excessive deficit procedure spurred an increased perception of risk. The markets priced a strong contagion hit into the nexus, which swung up and down until mid-2011, in association to the events reported in Table A.4 of the appendix.

Surprisingly, the August 2011 announcement by the ECB on the acquisition of sovereign bonds issued by Spain and Italy, which aimed to reduce the borrowing costs of these countries, failed to dent the conditional correlation coefficients. Possibly this unanticipated outcome was due to the interpretation of the announcement as a corroboration of the seriousness of the Greek debt crisis, which might involve the economies of Italy and Spain.

The long-term refinancing operations (TLTRO1, TLTRO2), of the end of December 2011 and of the last day of February 2012 respectively, reduced the dimension of the selected transition variables but failed to exert a long lasting effect on the strength of the within country nexuses, a result in line with the finding of Acharya et al. (2016). (Anecdotic evidence suggests that the lack of TLTRO efficacy be due to banks using the new funding to buy high yield domestic sovereign bonds, which reinforced the nexus.)

During most of the year 2012 additional events - despite their possible relief effects on the nexus - are associated only with temporary reductions in the correlations. Their subsequent visible reductions in France, Italy and Spain correspond to the new ECB bond-buying plan, the details of which were released in early September 2012. The famous "whatever it takes" on July 26th 2012 - considered as the turning point of the ECB monetary policy - became credible only when followed by an action plan in September, the so-called OMT.[12] For Germany, France and Italy, this policy measure caused a decline of the absolute connectedness, signaling a decline of total risk perceptions. As for Spain things are less clear-cut since in this very period the Spanish banking sector sought for financial assistance. This phase continued until the end of the year. In the first semester 2013, correlation regimes switched frequently to higher values. It is only after July 2013 that the connectedness measures of all countries stabilized at a lower level, as the recovery became more significant. At that time the euro zone officially emerged from the recession that had plagued it for a year and a half and Ireland became the first euro country to exit its bail-out program.

This respite lasted several months as the ECB declared its willingness to apply unconventional measures such as bond purchases or quantitative easing (April 2014). Only at the end of October 2014, when information about the results of Comprehensive Assessment exercise were leaked by press-agencies, did the strength of the nexus rise again. In the same way, the unexpected resumption of political turmoil in Greece, from December 2014 onwards, associated with the election of a far left government, was

[12] This finding too is in line with the outcome of the analysis of Acharya et al. (2016).

immediately reflected in an increase in the spread between the Greek and German bond yields. The corresponding increase in the bank sovereign CDS nexuses of Germany and France offset the positive effects of the monetary policies adopted by the ECB. In the first months of 2015 the Italian nexus alone showed signs of loosening and this remarkable result was probably due to domestic policy reasons.

5. Sovereign - bank nexus: cross country analysis

The sovereign - bank CDS nexus is usually understood to be a within country phenomenon. However, this relationship could also exist across countries of the Euro Zone. Its strength would then be affected by common monetary policy decisions and/or idiosyncratic fiscal shocks.

The relevance of the nexus can be seen as a proxy of the market perception of the overall riskiness of a country (the stronger the nexus, the higher the riskiness and vice-versa). We estimate therefore a VAR model of the STCC-GARCH conditional correlations between the daily rates of change of the CDS premia of sovereign and banking issuers within each country of the sample and analyze their spillover effects with the help of an impulse response function.[13]

<Insert Figure 3 around here >

From a visual inspection of Figure 3, it stands out that any shift of the German nexus affects those of France and Italy with a two days lag and instantaneously the Spanish one. Spain too exerts a cross border impact since a positive shock to its nexus determines a response of the Italian one which lasts almost a working week. This could be explained by the "sympathy" between the Spanish sovereign CDS premia and the Italian ones already detected in Alter and Beyer (2013, figures 1 and 3, pages 17 and 18). Contrary to common belief, changes in the Italian riskiness perception are to be considered but a contained phenomenon.

[13] The STCC-GARCH conditional correlation time series are obtained using the estimates in Table 2. The VAR order is set to 15, a selection based on the Akaike criterion.

Two additional factors could further reinforce cross border linkages: i) institutions other than the local sovereign can issue guarantees in favor of EMU banks and ii) Basle II allows to weight favorably euro bonds issued by EU sovereigns independently of the effective riskiness of the issuer. French and German banks will find it profitable, therefore, to buy bonds issued by Italy and Spain whenever their yields are higher than bond yields issued by core countries. Data on the latest stress tests of 2014 show that on average German and French banks hold in their sovereign bond portfolios – besides a share of domestic sovereign bonds of 53% and of 35% respectively – a relatively large share (from 15% to 20%) of peripheral sovereign bonds issued by the "GIIPS".[14] Hence we analyze the pattern of the correlation between the daily rates of change of the CDS premia of German and French banks, respectively, and the rates of change of the Italian and Spanish sovereign CDS premia.

In more detail, we estimate two systems. In the first one, the German bank bond CDS spread rate of change $(Dcdsb_t^{DB})$ is related to the Italian $(Dcdss_t^{IT})$ and Spanish $(Dcdss_t^{SP})$ sovereign bonds CDS spread rates of change, and in the second one the French bank bond CDS spread rate of change $(Dcdsb_t^{FR})$ is related to the Italian and Spanish sovereign bond CDS spread rates of change.

Equation (1) reads therefore as follows

$$\begin{aligned} Dcdsb_t^k &= a_{01} + \sum_{z=1}^{l^\circ} a_{z1} Dcdsb_{t-z}^k + u_{1t} \\ Dcdss_t^{IT} &= a_{02} + \sum_{z=1}^{h^\circ} a_{z2} Dcdss_{t-z}^{IT} + u_{2t} \\ Dcdss_t^{SP} &= a_{03} + \sum_{z=1}^{q^\circ} a_{z3} Dcdss_{t-z}^{SP} + u_{3t} \end{aligned} \qquad (1'')$$

where k = BD, FR.

The conditional variances and covariances become

$$h_{iit} = \omega_i + \alpha_i u_{it-1}^2 + \beta_i h_{iit-1}, \quad i = 1, \dots, 3 \qquad (4'')$$

[14] Banks in Italy and Spain invest heavily in domestic sovereign bonds (up to 90% of their bond portfolios). Percentage computed by the authors on the base of the stress test dataset released by the EBA.

$$h_{ijt} = \rho_{ij}(h_{iit}, h_{jjt})^{0.5}, \qquad 1 \le i < j \le 3 \qquad (5'')$$

$$\begin{bmatrix} h_{11t} & h_{12t} & h_{13t} \\ h_{21t} & h_{22t} & h_{23t} \\ h_{31t} & h_{32t} & h_{33t} \end{bmatrix} = \begin{bmatrix} h_{11t}^{0.5} & 0 & 0 \\ 0 & h_{22t}^{0.5} & 0 \\ 0 & 0 & h_{33t}^{0.5} \end{bmatrix} \begin{bmatrix} 1 & \rho_{12t} & \rho_{13t} \\ \rho_{21t} & 1 & \rho_{23t} \\ \rho_{31t} & \rho_{32t} & 1 \end{bmatrix} \begin{bmatrix} h_{11t}^{0.5} & 0 & 0 \\ 0 & h_{22t}^{0.5} & 0 \\ 0 & 0 & h_{33t}^{0.5} \end{bmatrix} \qquad (6'')$$

The time-varying conditional correlations are given by

$$\rho_{ijt} = (1 - G_t)\rho_{ij}^1 + G_t\rho_{ij}^2 , \qquad 1 \le i < j \le 3 \qquad (7'')$$

where G_t is, as usual, parameterized by the logistic function (8).[15]

Here too the selection of the STCC-GARCH is justified by the T-S-T LM tests. The model estimates in Table 3 are always highly statistically significant and the standardized residuals tests fail to find evidence of misspecification. An accurate selection process justifies the use of the change in the Greek-German bond spread as transition variable.

<Insert Table 3 around here >

<Insert Figure 4 around here >

From a visual inspection of Figure 4, it is possible to infer that - in both cases - cross border contagion has a similar pattern, even if the conditional correlation estimates of Table 3 highlight different intensities and speeds of reaction. In fact, for the German and French banks the correlation size is fairly similar denoting a comparable overall risk perception by market participants.

Bouts of high correlation are associated with periods of distress and, apart from the period prior to the 2008 crisis, there are three periods of relief lasting for a significant time span. In 2009 following the introduction of the enhanced credit support programme by the ECB; in mid-2010, when the regime shift lasted from May - when the ECB established the Security Market programme and the Euro area member states decided to create the European Financial Stability Facility, subject to conditions negotiated

[15] The order of the conditional mean autoregressions is always one ($h^{\circ} = l^{\circ} = q^{\circ} = 1$).

with the Troika - to November, when Ireland sought financial support; in mid-2013, from July - when the ECB revealed that key interest rates would remain at present or lower levels for an extended period of time - until October 2014. During this last period Greece managed to return to the financial markets and to issue Eurobonds.

The cross countries correlations increase towards the end of the sample, following press information leakages on banks' CA and an unanticipated rebound of the Greek crisis due to domestic political instability.

6. Conclusions

In this paper the nexus between bank and sovereign CDS spread rates of change is analyzed with the help of the STCC-GARCH model of Berben and Jansen (2005) and of Silvennoinen and Teräsvirta (2005). The selection of the transition variable, which is supposed to bring about a smooth regime switch, proves to be highly informative. In the two core countries of the sample, Germany and France, the transition variable is the change in the spread between the Greek and German long term sovereign bond yields. In the two peripheral countries, Italy and Spain, this role is played by the positive change in the sovereign and bank CDS bond spreads, respectively. Thus core country correlations react to a systemic factor, such as the Greek crisis, while the correlations in the periphery are affected by idiosyncratic elements, which in turn may possibly react to a systemic trigger. These results have significant policy implications: Quantitative Easing and TLTRO, i.e. the so-called unconventional monetary policy tools, directly affect the changes in the Italian and Spanish CDS bond spreads with a consequent impact on the (risk) nexus between sovereign and banks. But these measures are less effective on the risk nexus of the core countries. Indeed, France and Germany are mainly influenced by the vagaries of the Greek crisis and by the corresponding threat to the overall European project. Therefore, from a stand-alone perspective, the criticisms coming from these countries on the ineffectiveness of the recent ECB monetary policy stance seem to be justified by our findings. At the same time, the importance of the Greek crisis and the necessity for its speedy and credible solution must not be underestimated as any delay could impinge on the overall stability of the European financial sector.

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Table 1. Tests for constant conditional correlations

Constancy tests against DCC					
Type	Lags	Germany	France	Italy	Spain
Ljung Box*	1	16.286	2.809	10.009	5.310
		[0.000]	[0.093]	[0.001]	[0.021]
	5	26.569	20.884	19.640	12.819
		[0.000]	[0.001]	[0.001]	[0.025]
	10	37.802	39.451	23.405	20.518
		[0.000]	[0.000]	[0.009]	[0.024]
Bollerslev**	1	6.552	6.604	4.958	2.383
		[0.000]	[0.000]	[0.000]	[0.049]
	5	4.264	5.060	3.631	1.974
		[0.000]	[0.000]	[0.000]	[0.045]
	10	3.215	3.674	2.403	1.496
		[0.000]	[0.000]	[0.003]	[0.110]
Constancy tests against STCC					
T-S-T	Transition Variable	$\Delta GGsp_{t-3}$	$\Delta GGsp_{t-6}$	$\Delta cdss^{+}_{t-1}$	$\Delta cdsb^{+}_{t-5}$
		47.748	96.221	47.377	117.079
		[0.000]	[0.000]	[0.000]	[0.000]

Notes.*: Ljung Box test statistic of n-th order autocorrelation in the cross-products of the CCC-GARCH standardized residuals, distributed as χ^2 with n degrees of freedom; **: Bollerslev (1990) residual based F-test of the null of constant conditional correlation distributed as *F*(*n*,*n.obs*-*n*) where n indicates the number of lags set out in column 2; T-S-T: Tse (2000) and Silvennoinen and Teräsvirta (2005) LM test distributed as a χ^2 with N(N-1)/2 degrees of freedom, N being the number of variables of the multivariate GARCH; *n.obs:* number of observations. Probabilities in square brackets.

Table 2. Smooth transition conditional correlations – within country estimates

Conditional correlations								
Country	Germany		France		Italy		Spain	
Trans. Variable	$\Delta GGsp_{t-3}$		$\Delta GGsp_{t-6}$		$\Delta cdss^{+}_{t-1}$		$\Delta cdsb^{+}_{t-5}$	
ρ^{1}_{12}	0.4051 (32.5029)		0.2914 (26.1762)		0.3123 (26.2195)		0.2349 (25.0904)	
ρ^{2}_{12}	0.7165 (37.2709)		0.6706 (34.0635)		0.8036 (53.5579)		0.6447 (35.4326)	
ϒ	32.9423 (3.1123)		22.1395 (3.9221)		0.1776 (11.0974)		1.1077 (7.5890)	
C	0.1174 (9.5581)		0.1810 (10.6691)		4.4164 (11.3419)		2.5815 (11.9014)	
LLF	9946.4767		9059.7721		9439.3238		9186.5538	
Dep. Variable	$Dcdss_t$	$Dcdsb_t$	$Dcdss_t$	$Dcdsb_t$	$Dcdss_t$	$Dcdsb_t$	$Dcdss_t$	$Dcdsb_t$
Stand. Res.	$\frac{u_{1t}}{\sqrt{\varepsilon_{11t}}}$	$\frac{u_{2t}}{\sqrt{\varepsilon_{22t}}}$	$\frac{u_{1t}}{\sqrt{\varepsilon_{11t}}}$	$\frac{u_{2t}}{\sqrt{\varepsilon_{22t}}}$	$\frac{u_{1t}}{\sqrt{\varepsilon_{11t}}}$	$\frac{u_{2t}}{\sqrt{\varepsilon_{22t}}}$	$\frac{u_{1t}}{\sqrt{\varepsilon_{11t}}}$	$\frac{u_{2t}}{\sqrt{\varepsilon_{22t}}}$
AR(1)	6.856 [0.0088]	0.007 [0.7905]	1.156 [0.2823]	0.0000 [0.9812]	6.571 [0.0104]	2.614 [0.1059]	0.460 [0.4976]	2.801 [0.0941]
AR(2)	8.150 [0.0169]	0.411 [0.8142]	1.156 [0.5611]	0.0028 [0.9860]	6.583 [0.0572]	3.889 [0.1430]	1.421 [0.4913]	4.246 [0.1196]
AR(5)	11.059 [0.0502]	3.778 [0.5817]	6.778 [0.2376]	2.047 [0.8425]	7.782 [0.1686]	4.964 [0.4202]	2.055 [0.8414]	12.211 [0.0320]
ARCH(1)	4.047 [0.0442]	0.758 [0.3840]	10.719 [0.0010]	4.517 [0.0335]	5.006 [0.0252]	5.994 [0.0143]	0.216 [0.6424]	0.119 [0.7298]
ARCH(2)	4.054 [0.1317]	0.816 [0.6651]	11.236 [0.0036]	4.580 [0.1012]	5.127 [0.0770]	7.304 [0.0259]	2.297 [0.3171]	1.077 [0.5836]
ARCH(5)	5.356 [0.3739]	17.605 [0.0034]	13.940 [0.0159]	14.557 [0.0124]	6.624 [0.2501]	9.214 [0.1008]	6.553 [0.2560]	1.130 [0.9514]
JB	1981.977 [0.0000]	755.318 [0.0000]	9592.189 [0.0000]	672.864 [0.0000]	3511.826 [0.0000]	1530.590 [0.0000]	6673.598 [0.0000]	283215.9 [0.0000]

Notes. JB: Jarque-Bera normality test; AR(n): Ljung-Box test statistic for n-th order serial correlation; ARCH(n): Ljung-Box test statistic for n-th order serial correlation of the squared time series. Student t in round brackets; probabilities in square brackets; Subscript 1 stands for regime 1 (low correlation) and subscript 2 stands for regime 2 (high correlation).

Table 3. Smooth transition conditional correlations - cross border estimates

	Conditional correlations					
Country	Germany			France		
Transition Variable	$\Delta GGsp_{t-3}$			$\Delta GGsp_{t-6}$		
T-S-T	285.577 [0.0000]			191.880 [0.0000]		
ρ_{12}^{1}	0.4144 (39.9172)			0.4288 (43.4562)		
ρ_{13}^{1}	0.3824 (29.6156)			0.4066 (38.0856)		
ρ_{32}^{1}	0.5959 (144.6397)			0.5750 (126.0488)		
ρ_{12}^{2}	0.7343 (50.3971)			0.7132 (65.6136)		
ρ_{13}^{2}	0.6846 (37.4545)			0.6632 (55.1991)		
ρ_{32}^{2}	0.8747 (105.7906)			0.8708 (144.4385)		
ϒ	34.7794 (5.3874)			83.5134 (6.3774)		
C	0.1425 (30.6797)			0.0765 (47.7782)		
LLF	15031.2860			14988.6348		
Dependent variable	$Dcdsb_t^{BD}$	$Dcdss_t^{IT}$	$Dcdss_t^{SP}$	$Dcdsb_t^{FR}$	$Dcdss_t^{IT}$	$Dcdss_t^{SP}$
Standardized Residual	$\frac{u_{1t}}{\sqrt{\varepsilon_{11t}}}$	$\frac{u_{2t}}{\sqrt{\varepsilon_{22t}}}$	$\frac{u_{3t}}{\sqrt{\varepsilon_{33t}}}$	$\frac{u_{1t}}{\sqrt{\varepsilon_{11t}}}$	$\frac{u_{2t}}{\sqrt{\varepsilon_{22t}}}$	$\frac{u_{3t}}{\sqrt{\varepsilon_{33t}}}$
AR(1)	0.0001 [0.9972]	0.287 [0.5919]	5.066 [0.0244]	0.002 [0.8828]	0.249 [0.6179]	5.143 [0.0233]
AR(2)	0.458 [0.7953]	0.883 [0.6429]	5.611 [0.0604]	1.554 [0.4597]	0.853 [0.6527]	5.691 [0.0581]
AR(5)	4.092 [0.5363]	2.284 [0.8085]	6.380 [0.2710]	2.553 [0.7684]	2.258 [0.8124]	6.465 [0.2635]
ARCH(1)	1.541 [0.2144]	1.849 [0.1739]	0.408 [0.5230]	3.954 [0.0467]	1.826 [0.1765]	0.399 [0.5274]
ARCH(2)	2.648 [0.2661]	1.898 [0.3871]	0.819 [0.6638]	7.020 [0.0298]	1.878 [0.3910]	0.817 [0.6647]
ARCH(5)	20.161 [0.0011]	3.069 [0.6893]	2.455 [0.7832]	20.808 [0.0008]	3.069 [0.6893]	2.474 [0.7803]
JB	920.119 [0.0000]	15102.775 [0.0000]	6203.549 [0.0000]	891.439 [0.0000]	15044.431 [0.0000]	6190.971 [0.0000]

Notes. T-S-T: Tse (2000) and Silvennoinen and Teräsvirta (2005) LM test distributed as a χ^2 with N(N-1)/2 degrees of freedom, N being the number of variables of the multivariate GARCH; JB: Jarque-Bera normality test; AR(n): Ljung-Box test statistic for n-th order serial correlation; ARCH(n): Ljung-Box test statistic for n-th order serial correlation of the squared time series. Student t in round brackets; probabilities in square brackets; subscript 1 stands for rates of change in the banks CDS premia in Germany or France, depending on the column; subscript 2 stands for rates of change in the Italian sovereign CDS premia; subscript 3 stands for rates of change in the Spanish sovereign CDS premia. Superscript 1 stands for regime 1 (low correlation) and superscript 2 stands for regime 2 (high correlation).

Figure 1. Moving average correlations between bank and sovereign bonds CDS premia rates of change

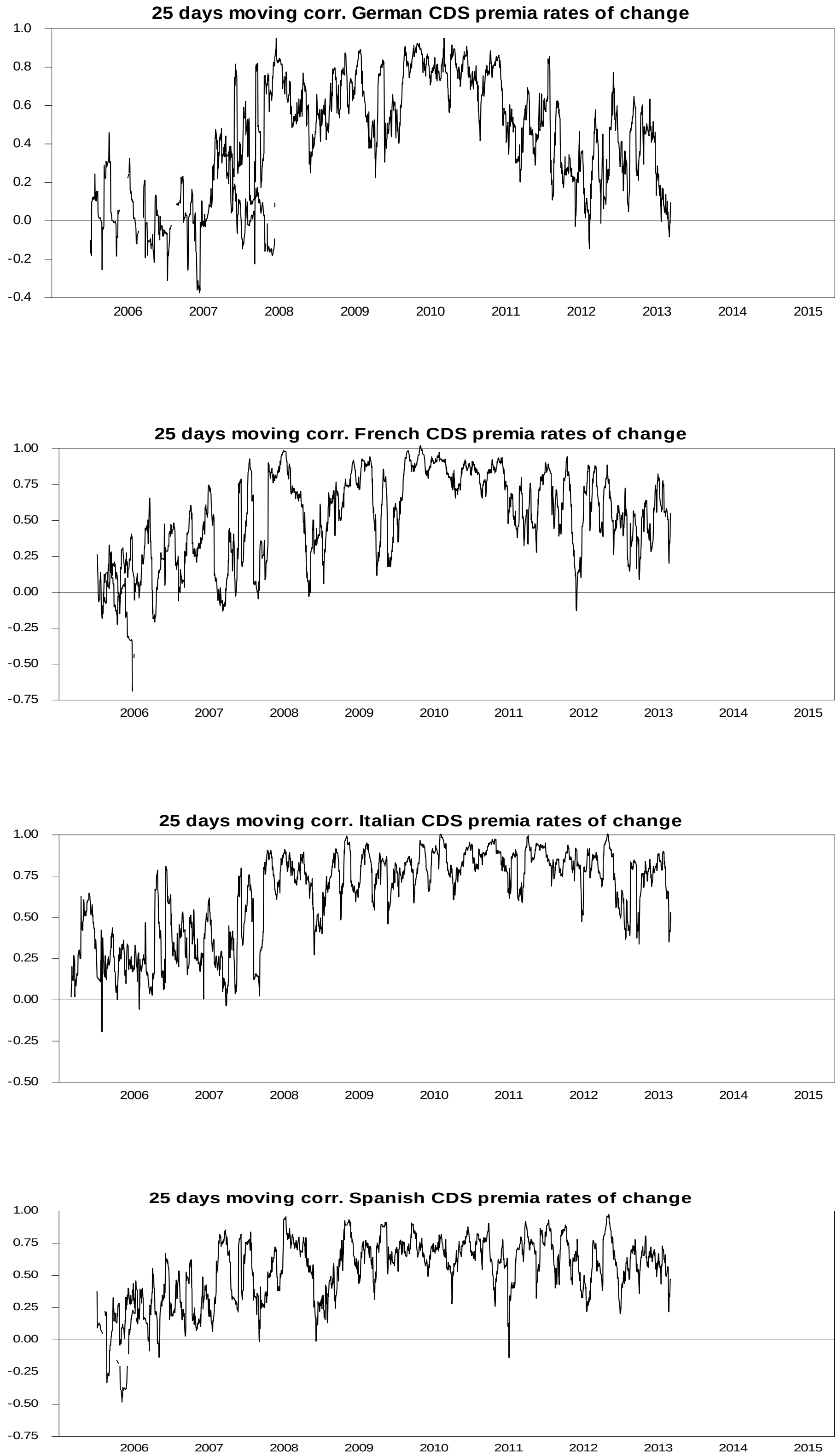
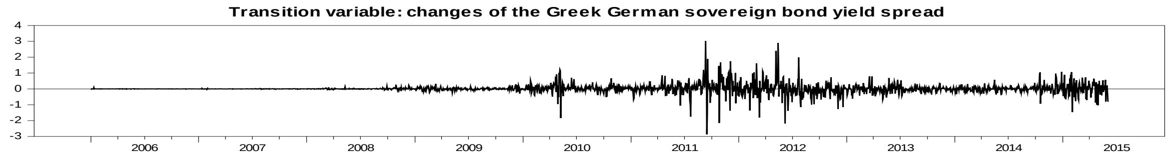
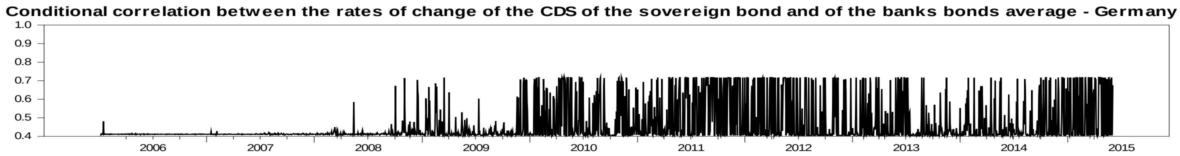


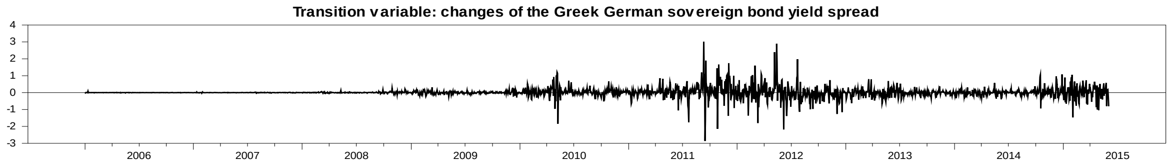
Figure 2. CDS within country smooth transition conditional correlations

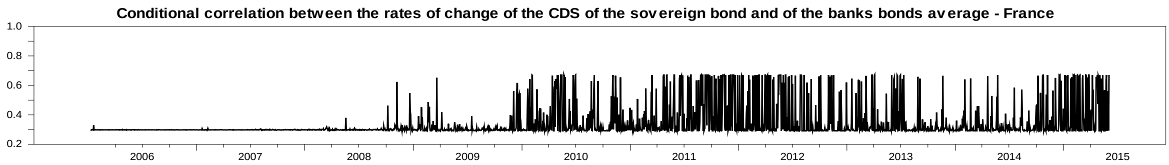
GERMANY



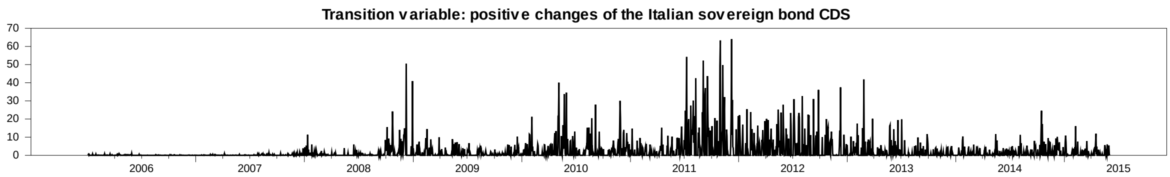


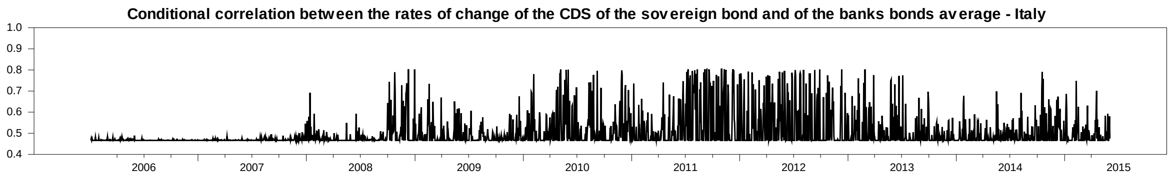
FRANCE



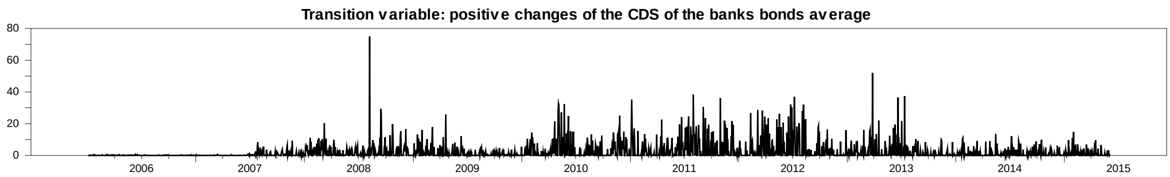


ITALY





SPAIN



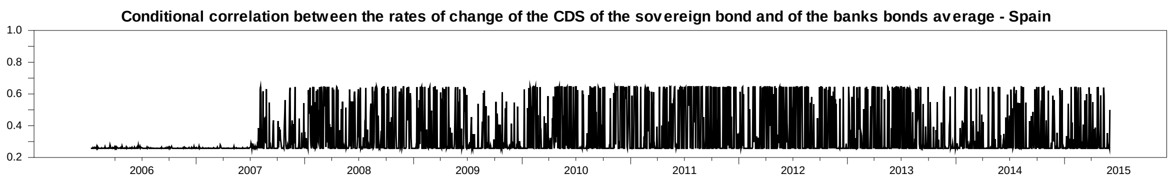
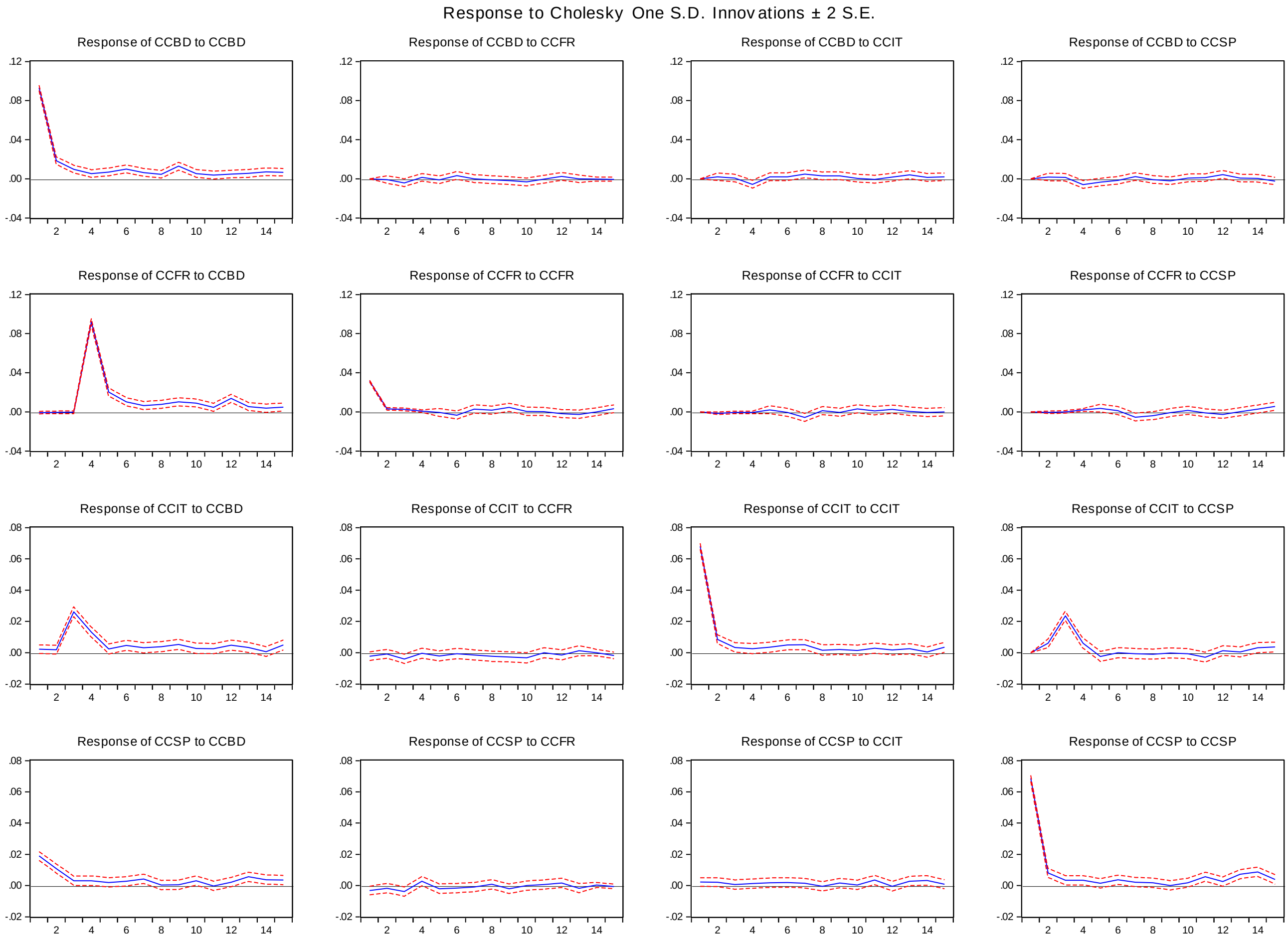


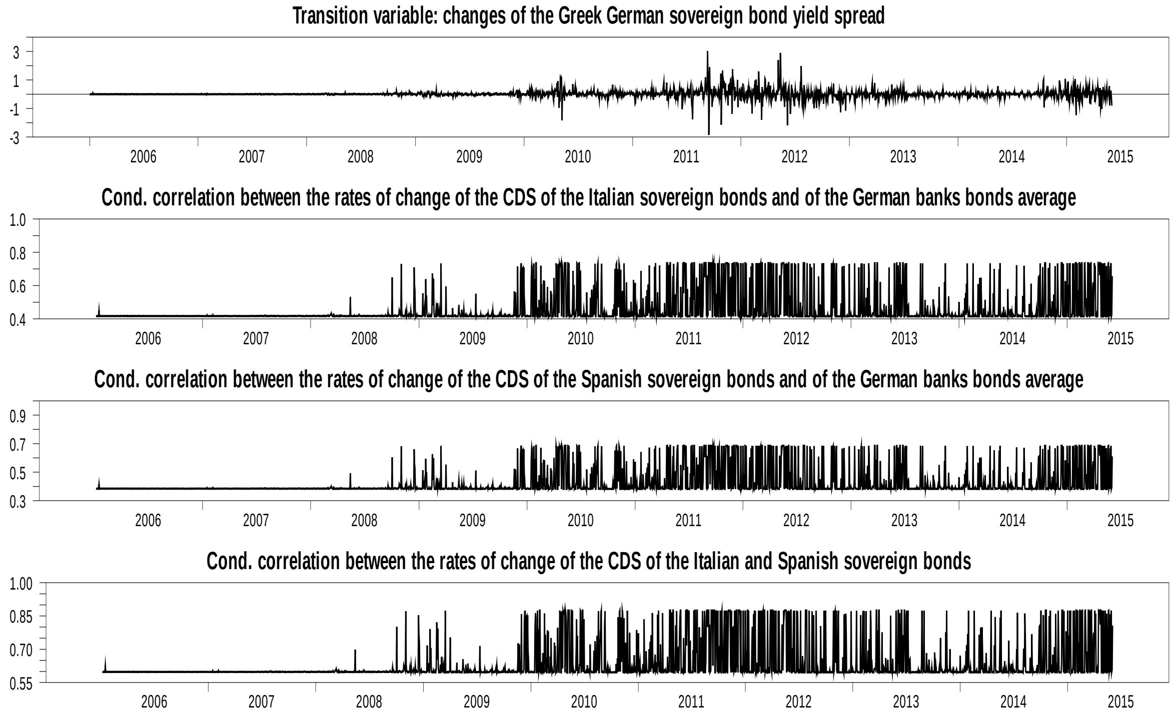
Figure 3. CDS Conditional correlations - VAR impulse response function



Notes. CCXZ: conditional correlation between the rates of change of the sovereign and bank CDS spreads of country XZ, obtained using the STCC-GARCH estimates of Table 2.

Figure 4 . Cross borders smooth transition CDS conditional correlations

GERMAN BANKS VS ITALIAN AND SPANISH SOVEREIGN



FRENCH BANKS VS ITALIAN AND SPANISH SOVEREIGN

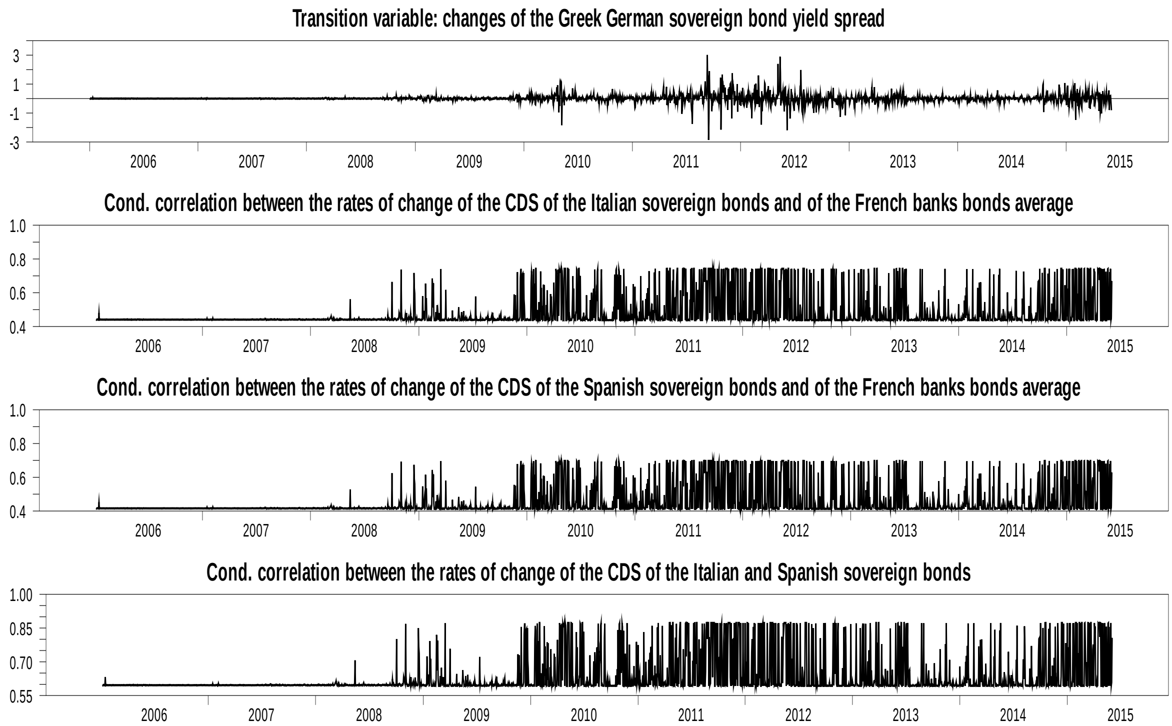


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Table A.1 Descriptive statistics

Variable	Mean	Std. Dev.	Skew.	Kur.	JB	AR(1)	AR(5)	ARCH(1)	ARCH(5)
Dcdss BD	0.0044	0.1037	10.79	253.54	6473642.00	112.97	122.92	31.24	31.36
					[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Dcdss FR	0.0035	0.0847	2.61	39.67	140432.20	166.45	174.01	80.15	363.51
					[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Dcdss IT	0.0020	0.0456	1.30	20.41	31715.16	2.33	4.75	53.47	174.21
					[0.00]	[0.13]	[0.45]	[0.00]	[0.00]
Dcdss SP	0.0024	0.0506	0.39	17.08	20360.29	0.92	12.93	21.93	253.94
					[0.00]	[0.34]	[0.02]	[0.00]	[0.00]
Dcdsb BD	0.0015	0.0405	1.59	23.42	43743.12	168.6900	173.5100	442.6200	789.8300
					[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Dcdsb FR	0.0017	0.0409	0.34	8.97	3692.33	171.6700	187.1600	181.0800	678.7600
					[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Dcdsb IT	0.0020	0.0483	1.29	15.42	16481.98	63.93	74.27	206.95	414.20
					[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Dcdsb SP	0.0019	0.0429	4.54	101.20	995657.30	47.41	56.17	0.82	1.57
					[0.00]	[0.00]	[0.00]	[0.36]	[0.90]
$\Delta GGsp$	0.0118	0.2930	0.54	26.72	57734.69	66.58	91.54	171.48	601.38
					[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
ΔVIX	0.0596	7.2255	1.27	9.35	4791.80	8.43	13.56	34.99	122.61
					[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Mcor BD	0.3268	0.2964	-0.08	1.94					
Mcor FR	0.3944	0.3405	-0.43	2.16					
Mcor IT	0.5391	0.2994	-0.88	2.57					
Mcor SP	0.3968	0.2759	-0.74	3.20					

Notes. BD = Germany, FR = France; IT = Italy; SP = Spain; D = daily rate of change; Δ = daily change; *Mcor* = time varying correlation moving average, computed over a 25-day time window; *cdss*: sovereign sector credit default spread (premium); *cdsb*: banking sector credit default spread (premium); *GGsp*: spread between Greek and German 10 years government bond yields; VIX: S&P100 index volatility Index; JB: Jarque-Bera normality test; AR(n): Ljung-Box test statistic for n-th order serial correlation; ARCH(n): Ljung-Box test statistic for n-th order serial correlation of the squared time series; probabilities in square brackets.

Table A.2 Granger causality tests between sovereign and domestic bank bonds CDS daily rates of change (lag =10)

Null Hypothesis: X	does not cause Y	F-STAT	PROB	N. OBS
Dcdss FR	*Dcdsb* FR	2.7839	0.002	2447
Dcdsb FR	*Dcdss* FR	3.6815	7.E-05	2447
Dcdss BD	*Dcdsb* BD	1.1893	0.293	2447
Dcdsb BD	*Dcdss* BD	4.6439	1.E-06	2447
Dcdss IT	*Dcdsb* IT	3.9728	2.E-05	2447
Dcdsb IT	*Dcdss* IT	6.0727	4.E-09	2447
Dcdss SP	*Dcdsb* SP	4.5891	2.E-06	2447
Dcdsb SP	*Dcdss* SP	3.2988	0.000	2447

Table A.3 Pearson correlation coefficients between sovereign and domestic banks bonds CDS premia rates of change.

	BD	FR	IT	SP
	Full sample			
Correlations	0.1192	0.1931	0.4369	0.2922
	[0.000]	[0.000]	[0.000]	[0.000]
Sample A	*1/03/2006 – 5/18/2011*			
Correlations	0.0839	0.1377	0.3306	0.2296
	[0.000]	[0.000]	[0.000]	[0.000]
Sample B	*5/19/2011 – 9/06/2012*			
Correlations	0.6813	0.7662	0.7764	0.5125
	[0.000]	[0.000]	[0.000]	[0.000]
Sample C	*9/07/2012 – 6/03/2015*			
Correlations	0.2327	0.4301	0.673	0.4788
	[0.000]	[0.000]	[0.000]	[0.000]
	Difference in correlation between sample B and sample C			
Difference	0.4486	0.3361	0.1034	0.0337
Fisher Z transformation	9.01	8.35	3.33	0.68
P-value one tailed	[0.000]	[0.000]	[0.000]	[0.240]
P-value two tailed	[0.000]	[0.000]	[0.000]	[0.500]

Notes. Probabilities in square brackets.

Table A.4 Timeline of the European Crisis

08.09.2007	Liquidity crisis due to subprime exposure affects mainly the US and the UK.
09.15.2008	Lehman crisis.
07.13.2009	Governor Trichet explains the "enhanced credit support programme" of the ECB.
03.10.2009	The ECB council issues a budgetary warning against Greece under the excessive deficit procedure.
12.02.2009	The ECB council judges that Greece has not responded adequately to its March warning.
04.21.2010	The EC/IMF/ECB troika arrives to Athens
05.14.2010	The ECB establishes the Security Market Programme.
11.21.2010	Ireland seeks financial support; the EU-IMF package for Ireland is agreed the following day.
04.07.2011	Portugal asks for support by the Eurozone; aid to Portugal is approved the following day.
07.15.2011	Stress test results are published by the EBA.
08.07.2011	The ECB announces that it will buy Italian and Spanish government bonds in order to bring down their borrowing costs, as concern grows that the debt crisis may spread to the larger economies of Italy and Spain.
11.03.2011	The ECB publishes details of the second covered bond purchase programme (the decision to launch the CBPP2 is taken the 10th of June 2011) and unexpectedly reduces the key interest rates because of recession fears.
11.08.2011	The Italian Prime Minister, Berlusconi, resigns. The Monti Government is assembled in the following days.
12.22.2011	The ECB auctions € 498 bn in its 3 year LTRO1.
01.13.2012	S&P downgrades the sovereign debt rating of 10 Euro-Zone countries, including France, Italy and Spain.
02.29.2012	The ECB announces that banks borrowed €529.5 bn during its second long–term refinancing operation (TLTRO2).
05.09.2012	Spanish government rescues Bankia, which is later entirely nationalized.
06.09.2012	Announcement that Spain will seek financial assistance for its banking sector; financial aid is granted the 20th of July.
07.26 2012	Draghi promises that the ECB would do "whatever it takes" to sustain the euro; his speech marks the turning point of the crisis.
09.06.2012	Details of the new bond-buying plan of the ECB, denominated Outright Monetary Transaction (OMT), are announced. Subsequently, the bond yields of Spain and Italy decline.
07.04.2013	The ECB reveals that key interest rates will remain at present or lower levels for an extended period of time. It is the first time that the ECB makes a commitment regarding interest rates.
08.14.2013	The euro zone officially emerges from a recession that had plagued it for a year and a half, posting a GDP growth rate of 0.3 percent. The news is greeted with guarded optimism. Germany remains the engine of European growth, however. Unexpectedly strong numbers from Portugal indicate that it is beginning to recover from its deepest recession in a quarter century

12.13.2013	Ireland becomes the first euro-zone country to exit its bailout program, stating that it will request no additional funds from the troika. The announcement is offered as evidence of the success of austerity policies, and Irish officials pledge to continue those measures in an effort to reduce the country's debt.
04.03.2014	The ECB states that it is disposed to apply unconventional measures such as bond purchases or quantitative easing. In response, the yields of periphery countries fall.
04.10.2014	Greece returns to financial markets and issues Eurobonds.
10.22.2014	Leak of information on the CA results by EFE a Spanish press-agency.
10.24.2014	Bloomberg News reports that exactly 25 banks have failed the stress test. Other leaks from domestic press anticipate the reaction of stressed banks to stress tests.
10.26.2014	Stress test and CA results are released to the public by the ECB.
12.29.2014	The Greek Government resigns.
01.22.2015	The ECB announces it will launch an expanded asset purchase program, encompassing the existing purchase programs for asset–backed securities and covered bonds. Private and public sector securities could be purchased.
01.25.2015	Far left parties win the Greek elections.

Source: ECB, Stratfor website
https://www.stratfor.com/topics/economics-and-finance/europes-economic-crisis