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## The Impact of the Eurozone Crisis on European Banks Stocks Contagion or Interdependence?\*

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Jean-Pierre Allegret<sup>1</sup>, H el ene Raymond<sup>2</sup> and Houada Rharrabti<sup>3</sup>

**Abstract:**

*This paper analyzes the influence of successive crises, including the recent European sovereign debt crisis, on banks' equity returns from 11 countries. Our data span the period December 14<sup>th</sup> 2007-March 8<sup>th</sup> 2013 that encompasses different episodes of economic and financial turmoil since the collapse of the subprime credit market. Our contribution to the literature is twofold. First, we use an explicit multifactor model of equity returns extended with a sovereign risk factor. Second, we adopt a Smooth Transition Regression (STR) framework that allows for an endogenous definition of crisis periods and captures the changes in parameters associated with shift contagion. We find that contagion from the European sovereign debt crisis to banks' equity returns has been confined to European banks, as U.S. banks' equity returns were unharmed by its direct impact and may even have benefited from a kind of flight to quality effect. Besides, across banks from the euro area, German financial institutions have not been completely spared by the eurozone debt crisis, though they have been relatively less affected.*

**Key words:** *Smooth Transition Regression model, European sovereign debt crisis, Banks' equity returns, Contagion, Interdependence.*

**JEL Code:** E6; F3; G2

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## **1. Introduction**

The 2007-2009 crisis began by intense tensions in the financial systems of advanced economies and unraveled into a dramatic contraction in global growth. To prevent a larger collapse in economic activity, governments and central banks intervened massively in order to support aggregate demand – via automatic stabilizers and discretionary expenditures - and to bailout financial institutions. As a result, public finance experienced a marked degradation, leading to the emergence of the eurozone sovereign debt crisis as a new phase of the global crisis.<sup>1</sup> According to the IMF Fiscal Monitor, the fiscal deficit in advanced countries<sup>2</sup> moves from 1.3% of the GDP in 2006 to 8.9% in 2009 while the public debt in percentage of the GDP climbed from 75.8 to 93.7 over the same period. The degradation in public finance has been more dramatic in the euro area, and more specifically in its peripheral countries. Thus, the average fiscal deficit in Greece, Ireland, Italy, Portugal, and Spain (GIIPS-group) increased from 1.6% of the GDP in 2006 to 11.2% in 2009, while their public debt surged from 68.4% to 89.6% (with a projected peak at 130.5 percent of the GDP).

Any drop in the market value of European sovereign debt has a negative impact on the balance sheets of European banks. Banks hold large amounts of government bonds to satisfy multiple purposes. First, investing in government bonds allows financial institutions to diversify their portfolio into low risk assets. The European prudential regulation has encouraged banks to hold such safe and liquid securities that may help to cushion losses on riskier assets. Second, holding government bonds is crucial for banks to access the central bank liquidity, insofar as the refinancing operations of the central bank are based on highly rated securities. Besides, interbank loans and repos rely heavily on the use of public bonds as collaterals. Therefore, when the value of sovereign bonds plummets it reduces both the market value of these assets in banks' balance sheets and banks' access to funding. These large holdings of eurozone government bonds by European banks have led to a growing concern about possible spillovers from the sovereigns to the banks and a second round of spillovers from banks to sovereigns. Caruana and Avdjiev (2012) identify various channels of transmission from sovereign risks to the financial sector. First, they stress the impact of direct portfolio exposures. The Committee on the Global Finance System estimates that, for a sample of 21 advanced economies<sup>3</sup> at the end-2010, the banks' exposures to the domestic sovereign, measured as a percentage of banks' equities, have been above 30 percent in all countries except

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<sup>1</sup> For an overview, see Brender et al. (2013).

<sup>2</sup> Advanced countries include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, the Netherlands, Portugal, Spain, the United Kingdom, and the United States.

<sup>3</sup> Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, Poland, Portugal, Slovenia, Sweden, Spain, Switzerland, the United Kingdom, and the United States.

Austria, Ireland, and the United Kingdom (CGFS, 2011). On average, 85 percent of this exposure is held in the banking book. It is important to stress that the holding of government bonds is characterized by a strong home bias. Second, as sovereign bonds are used by banks as collaterals, a decrease in the quality of government debt may lead to a significant deterioration of funding conditions for financial institutions.<sup>4</sup> A third channel of transmission from sovereigns to banks resides in the fact that a marked increase in sovereign credit risk may trigger doubts on the ability of the governments to offer a credible guarantee to banks and / or financial supports in case of distress. In other terms a sovereign domestic debt crisis decreases the value of the explicit and implicit government guarantees that benefit banks that are considered too big or too interconnected (TBTF) to be allowed to fail. As these guarantees amount to very significant government subsidies (Schich and Lindh, 2012) their impairment may have a large negative impact on TBTF banks' balance sheets.

This paper contributes to the growing literature on the European sovereign debt crisis by focusing on the impact of the successive crises on banks' equity returns over the period 2007-2013. Whereas most papers of the related literature do not rely on an explicit theoretical model of stock returns, we start from a variant of the multifactor model of Fama and French, extended by Carhart (1997), to control for the different channels of risk transmission to banks' stocks. More specifically, we modify the four-factor model of Carhart (1997) in two ways. First, we add the sovereign risk factor – proxied by the sovereign CDS - as an explanatory variable of banks' equity returns. Second, we adopt a nonlinear specification to account for the nonlinearities and, more specifically the shift contagion (Forbes and Rigobon, 2001), that may derive from the successive crisis episodes. So far the literature on the consequences of the European sovereign debt crisis for the banking sector has mainly captured these nonlinearities through dummy variables associated to crisis periods or to extreme events. We use a Smooth Transition Regression (STR) model that allows for an endogenous definition of crisis periods, smooth transitions and captures the shifts in parameters associated with shift contagion. We estimate this model for a sample of 11 countries, using daily data from December 14, 2007 to March 8, 2013.<sup>5</sup>

Our major findings are twofold. First, our results suggest that contagion from the European sovereign debt crisis to banks' equity returns has been confined to European banks, as U.S. banks' equity returns did not significantly react to the crisis. Second, across banks from the euro area, we show that German financial institutions have been relatively less affected by the sovereign debt crisis. Indeed, for Germany nonlinearities are observed only for very high values of the transition variable that appear exclusively in the immediate aftermath of Lehman Brothers' collapse.

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<sup>4</sup> See also CGFS (2011) and van Rixtel and Gasperini (2013).

<sup>5</sup> Table A1 in Appendix gives the list of countries and banks studied in this paper.

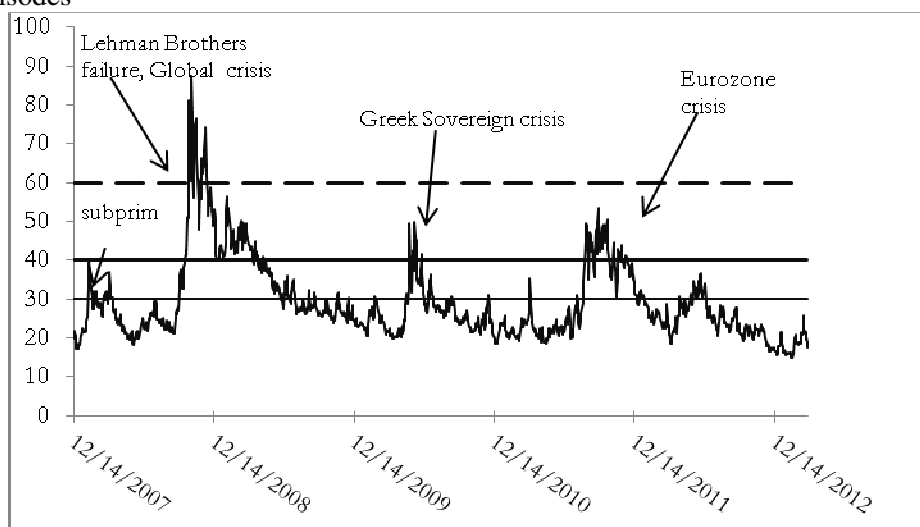
The rest of this paper is organized as follows. Section 2 presents a preliminary look at the data on the interactions between banks and sovereign risks and at the main related literature. Section 3 introduces the model and analyzes the main results. Section 4 concludes.

## **2. The Impact of the Sovereign European Debt Crisis: A Preliminary Look at the Data and the Related Literature**

### Data

Our data span the period 14/12/2007-08/03/2013 that encompasses four episodes of crises, namely: the subprime crisis of 2007/2008, followed by the global crisis after the failure of Lehman, Brothers, then in 2010 the Greek crisis, followed by the eurozone crisis. As exhibited by Figure 1, high levels of stock market volatility – captured through a VSTOXX above thresholds of 30 and 40 – characterize these crises.

**Figure 1:** Implied volatility on European Stock Market (VSTOXX) and crisis episodes



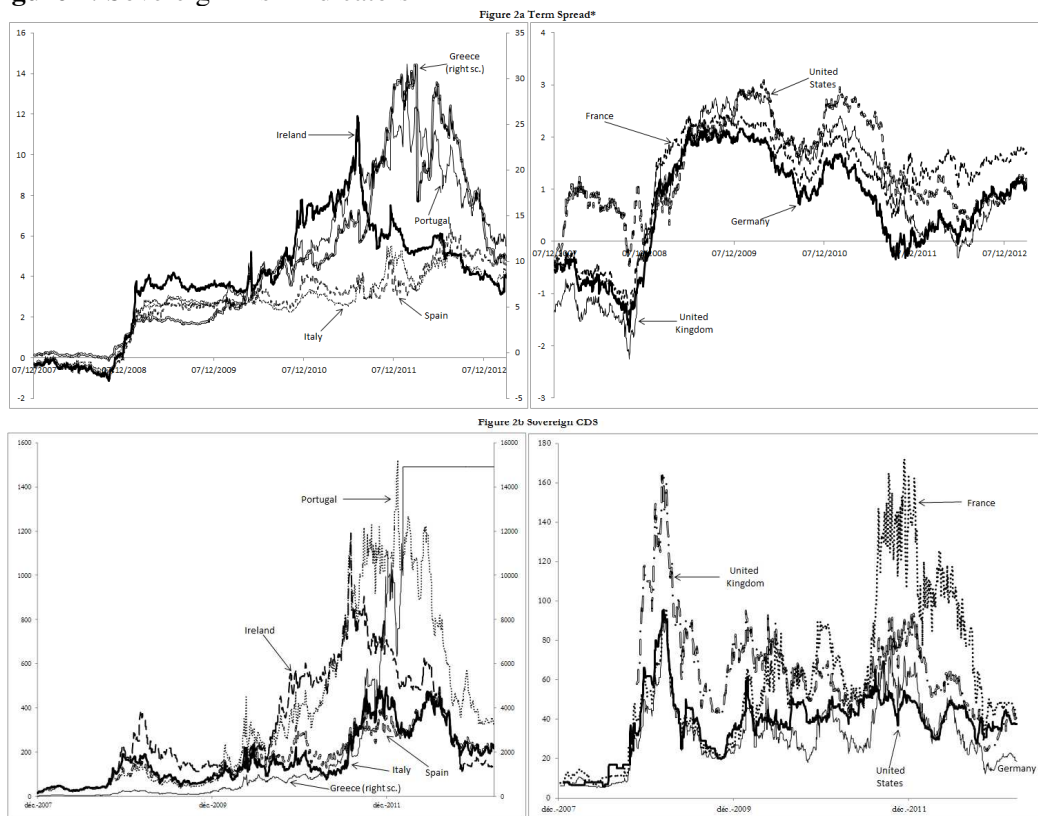
Source: data extracted from Macrobond

Though dependent, these four episodes present some differences: the period following the collapse of Lehman Brothers is clearly characterized by a record volatility, much higher than the levels observed during the three other crisis episodes. The two last crises are not only characterized by a more subdued volatility, they are also much more local crises, mainly focused on European countries.

During the subprime crisis episode, Figure 2 shows that the sovereign risk indicators do not significantly react. Indeed, neither the term spread (Figure 2a) – a measure of market expectations about future conditions in the financial markets – nor the

sovereign CDS (Figure 2b) increase in the aftermath of the collapse of the U.S. subprime credit market.

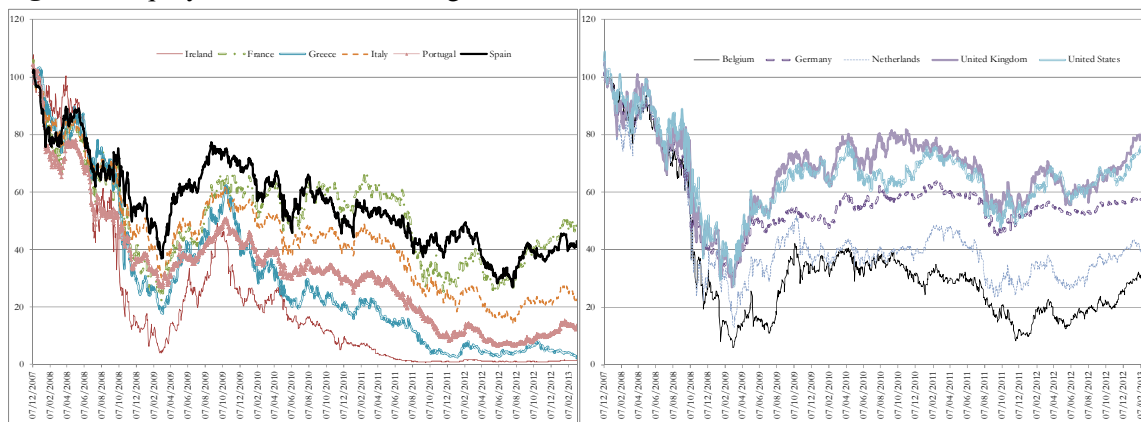
**Figure 2: Sovereign Risk Indicators**



\* 10 year Government bond yield minus 1 year LIBOR rate.  
 Source: data extracted from Datastream and Macrobond.

On the contrary, the banking sector experiences visible strains during this first episode of the global financial crisis. Indeed, not only do banks' equity prices decrease (Figure 3), but risk indicators on the interbank markets exhibit signs of stress.

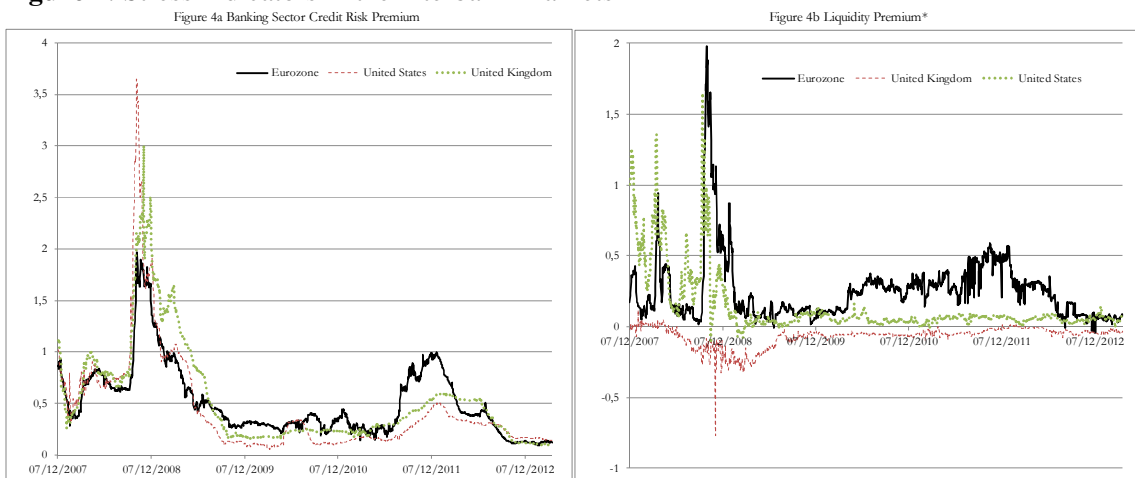
**Figure 3:** Equity Prices of the Banking Sector, 100 = 7<sup>th</sup> December 2007\*



\* Equity index have been estimated using our sample. See Appendix A1.  
Source: data extracted from Datastream.

To portray the stress on the interbank market, we follow Eichengreen et al. (2012) and split the TED spread into two components. The first component (Figure 4a) refers to the banking sector credit risk premium, estimated by the difference between the LIBOR rates and the overnight index swap (OIS). The second (Figure 4b) is the liquidity risk premium measured as the OIS minus the Treasury bill rate.

**Figure 4:** Stress Indicators in the Interbank Markets

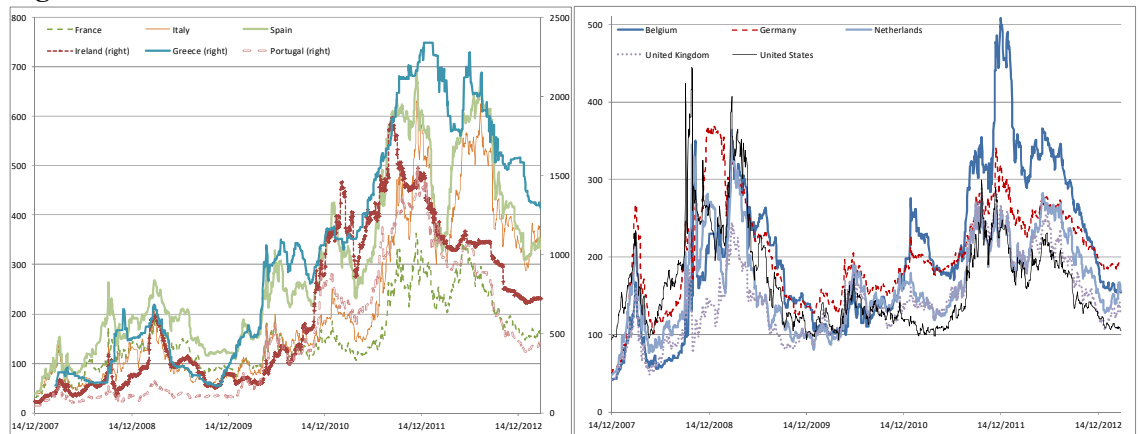


\* For the eurozone, we use the German Treasury bill as benchmark.  
Source: data extracted from Datastream and Macrobond.

The turning point in the evolution of the global financial has been the collapse of Lehman Brothers on the 15<sup>th</sup> September 2008. Indeed, all risk indicators

dramatically increase in the aftermath of this shock. For instance, we observe intense strains on the interbank markets (Figures 4a and b). In a similar way, as doubts increase on the health of the banking sector, banks' CDS rise during this second episode of the global financial crisis (Figure 5). Interestingly, we see that banks' CDS do not strongly react in the European peripheral countries, suggesting that market concerns have been initially focused on major advanced economies.

**Figure 5:** Banks' CDS



Source: data extracted from Datastream.

More importantly for our purpose, the collapse of Lehman Brothers has changed the strategy adopted by authorities to face banking instability. Indeed, while official bailouts have been implemented on a case by case basis before this event, the breadth of the financial crisis following this failure has led authorities to adopt systematic bailout programs. As a result, public finance experiences a significant degradation leading to increased interactions between banks' and sovereigns' risks. Acharya et al. (2013) find that in the pre-bailout period – that is before the announcement of the bailout in Ireland in late September 2008 - no clear relationship between banks' and sovereigns' CDS is identified. The situation changes in the aftermath of the bailouts. In a similar way, Mody and Sandri (2012) consider that the nationalization of Anglo-Irish in January 2009 has played a decisive role in the increase in the sensitivity of the sovereign's spread to the weakness of the financial sector.<sup>6</sup>

The Greek sovereign debt crisis that unraveled in 2010 marks a new phase in the development of the global financial crisis. Indeed, the onset of this crisis has increased the implied volatility on the European stock market after a period of



relative tranquility (Figure 1). Above all, the spreading of the crisis to many European countries - the so-called GIIPS (Greece, Ireland, Italy, Portugal, and Spain) - has boosted up risk indicators concerning both banks and sovereigns. Three points are especially important for our purpose. First, even if banks from the GIIPS have been particularly affected by the crisis, banks from other countries - and especially from the eurozone - were also impacted. For instance, Figure 3 exhibits a decrease in banks' equity prices in all eurozone countries suggesting the presence of contagion effects inside the monetary union. Second, periods of stress and tranquility have alternated since the beginning of the eurozone crisis, following the progress accomplished by European institutions, including the European central bank, to solve the sovereign debt crisis (Table 1).

**Table 1:** Main measures taken to solve the eurozone crisis

March 2010	The European Union offers support to Greece
May 2010	The European Union launches the European Financial Stability Facility
May 2010	The European Central Bank starts Securities Market Program
July 2010	Stress tests results
July 2011	The European Union offers a second support to Greece
December 2011	The European Central Bank launches the 1 <sup>st</sup> Long-Term Refinancing Operations
February 2012	The European Central Bank launches the 2 <sup>nd</sup> Long-Term Refinancing Operations
February 2012	The European Commission launches the Alert Mechanism Report
August 2012	The European Central Bank launches the Outright Monetary Transactions program
October 2012	The European banking union project

Third, the behavior of U.S. and U.K. risk indicators suggests that the spillovers from the eurozone crisis to these countries have been limited. During the debt crisis the U.S. and U.K. sovereign CDS increased much less than the sovereign CDS of the eurozone (Figure 2b). The difference is even more striking if we consider equity prices (Figure 3). Indeed, while the U.S. and U.K. equity prices of the banking sector experienced a recovery after the trough in March 2009, equity prices in the eurozone increased only slightly in the core economies of the eurozone and remained depressed in the GIIPS. Lastly, if Figure 4a suggests that there might be some negative spillovers from the eurozone crisis to the U.S. and U.K. interbank markets their impact appears to be relatively weak. These conjectures are further strengthened by the observation that the U.S. and U.K. liquidity premiums (Figure 4b) do not react to the eurozone sovereign debt crisis developments.

## Literature

Our study is closely related to two strands of the existing literature. The first one investigates the determinants of equity returns and credit risks in the banking sector. The second strand analyzes the extent of contagion from the sovereign debt crisis to banks.

Alter and Schuler (2012) contribute to the first strand of the literature. They examine whether the sovereign default risk exerts an influence on the default risk of the banking sector in the eurozone. To this end, they consider daily credit default swap (CDS) spreads from 7 eurozone member states and 21 banks over the period June 2007-May 2010. Their main aim is to determine to what extent these CDS spreads' interdependencies differ before (June 2007-mid-September 2008) and after (late-October 2008-May 2010) the implementation of bank bailout programs by European governments and institutions. They find that, while before the bailouts the sovereign CDS spreads affect only marginally the bank CDS spreads from the same country, their influence tends to become permanent in the period following the implementation of the bailout programs. Gross and Koky (2013) show – over a sample comprising 23 sovereigns and 41 banks from Europe, the United States, and Japan from January 2008 to April 2013 - that sovereign-to-bank spillovers have been particularly intense in 2011-2012 when the euro area sovereign debt crisis was at its peak. Arnold (2012) examines spillover of sovereign risk to the banking sector by introducing interactions effects that measure the level of exposure to GIPS - based on July 2010 stress tests - and whether the bank originates from GIPS (Greece, Ireland, Portugal, and Spain). Arnold (2012) estimates co-variations between combined GIPS Sovereign CDS spreads and banking risks during time windows centered on the weekend of May 8-9, 2010.<sup>7</sup> Banking risks are measured with banks' stock returns and CDS rates.<sup>8</sup> Two results are especially interesting. First, an increase in the combined Sovereign CDS rates in GIPS exerts a negative influence on the banking sector risk (i.e. banks' CDS spread increase and banks' stock returns fall). Second, banks heavily exposed to GIPS seem stronger impacted by the increase in sovereign CDS spread, but this result is mainly driven by banks originated from the GIPS.

Poirson and Schmittman (2013) estimate a variant of the world Capital Asset Pricing Model (CAPM) with a country-specific factor. Their sample includes daily stock returns from December 2002 to November 2011 for 83 banks from 21 countries. Results suggest that the sensitivity of banks to global factors (beta of the global factor) increases in times of strong market volatility: in 2008-2009 in the aftermath of Lehman Brothers collapse and in 2011 with the European debt crisis.

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<sup>7</sup> Two time windows are considered: one month and two months. On 8-9 May, 2010, European Union members agreed to implement a rescue funds for governments experiencing refinancing problems in bond markets.

<sup>8</sup> The sample includes 51 banks drawn from the 91 banks that participated in the July 2010 stress tests for which CDS rates and stock prices are available.

Interestingly, Poirson and Schmittman (2013) confirm the findings by Chan-Lau et al. (2012) concerning the regional dimension of the European debt crisis: the European debt crisis affects more European banks (including the United Kingdom) than banks located in other regions. In addition, Chan-Lau et al. (2012) stress that bank-specific characteristics matter, as higher capitalization, lower leverage, and less reliance on wholesale funding improve the resilience of banks (equity returns).

The second strand of the relevant literature investigates more directly contagion effects from sovereign debt crises to the banking sector.

De Bruyckere et al. (2013) define contagion as “excess correlation”, that is to say a correlation over and above that resulting from economic fundamentals. Their study covers 15 countries and 40 banks over the period 2007-2012. De Bruyckere et al. (2013) get three major findings. First, they identify significant evidence of contagion between banks and sovereigns CDS spreads during the European debt crisis. Second, as banks’ government exposures exhibit home bias, they show that contagion effects are stronger between banks and their home country. Third, as previous studies, the intensity of contagion is influenced by bank-specific characteristics. For instance, bank capital adequacy and the extent of reliance on short-term sources influence the degree of contagion. Alter and Beyer (2014) quantify the sovereign-banks feedback loop using daily sovereign and bank CDS spreads from 11 eurozone countries and 34 banks over the period October 2009-July 2012. An interesting contribution of this paper is the elaboration of a “Contagion Index” decomposed into four components: (i) amongst sovereigns, (ii) amongst banks; (iii) from sovereigns to banks, and (iv) from banks to sovereigns. The paper finds an upward trend concerning both the contagion index of sovereigns and the overall contagion index. In periods of stress, the feedback loop intensifies. Finally, shocks on Spanish sovereign CDS spread suggest that “non-core” countries (Greece, Ireland, Italy, and Portugal) are more sensitive than “core” countries (Austria, Belgium, Finland, France, Germany, and the Netherlands), but the difference between these groups decreases during times of distress.

Contrary to the two above mentioned papers Grammatikos and Vermeulen (2012) base their study of the contagion from sovereigns to the banking sector on banks’ equity returns. More specifically they examine the sensitivity of daily stock returns of financial firms and non-financial corporations in 11 eurozone members to the U.S. stock returns, the euro-dollar exchange rate and the gap between Greek and German CDS spreads. In order to detect contagion they use dummy variables to test whether there is a shift in some of the coefficients during crises.<sup>9</sup> On the one hand, the authors find the presence of shift contagion as the transmission of shocks is stronger during the 2007-2010 crisis. On the other hand, after the collapse of Lehman Brothers stock returns of financial firms have been more sensitive to

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<sup>9</sup> To determine the starting point of the financial crisis, Grammatikos and Vermeulen (2012) follow the Federal Reserve Bank of St. Louis’ crisis timeline.

changes in the Greek-German sovereign CDS spread. This suggests a contagion from sovereigns to banks. In a similar vein, Bhanot et al. (2014) investigate the impact of changes in Greek bond yield spreads on the daily abnormal financial sector returns in euro area crisis countries (Portugal, Italy, Greece, and Spain) and in euro area non-crisis countries (Austria, Belgium, France, and the Netherlands) from January 2005 to June 2011. They assess whether changes in the Sovereign Greek bond yield exhibit stronger impact in crisis periods or in the aftermath of news announcements. Like Grammatikos and Vermeulen (2012) they rely on a crisis dummy. Bhanot et al. (2014) also explore for evidence of news spillovers. To this end, they collect news announcements for Greece and the rest of the euro area and construct good and bad news dummies. Bhanot et al. (2014) find evidence of spillovers from the Greek bond yield to eurozone financial stock returns on days when there are ratings downgrades, suggesting the presence of information effects. In addition, they show that non-crisis countries are affected by ratings downgrades and bad news concerning Greece from the European Commission and the International Monetary Fund.

Overall the results of the related literature point at some nonlinear transmission of shocks to banks during the period 2007-2011 and, more specifically, at some spillovers from the GIPS Sovereign debt crisis to the banking sector. We contribute to this literature in two ways. First, by using a multifactor model of banks' stock returns to control more comprehensively for the different channels of risk transmission to banks' stocks. Second, through a nonlinear modelling, allowing for an endogeneous definition of crisis periods and for a smooth transition between regimes. The model and the methodology used are presented in detail in the next section.

### 3. Methodology and Results

#### The Model

To assess whether and how the stock returns of European and U.S. banks have been impacted by the sovereign European debt crisis and by the previous episodes of financial turmoil experienced since 2007 we start from the four-factor model of Carhart (1997):

$$R_{p,t} = \alpha + \beta_M R_{M,t} + \beta_{SMB} R_{SMB,t} + \beta_{HML} R_{HML,t} + \beta_{MOM} R_{MOM,t} + \varepsilon_{p,t} \quad (1)$$

Where  $R_{p,t}$  is the excess return of banks stocks over the risk free interest rate,  $R_{M,t}$  is the excess global stock market return over the risk free interest rate,  $R_{SMB,t}$  is the spread between the returns on small and big stocks,  $R_{HML,t}$  is the spread between the returns of high book-to-market stocks (value stocks) and low ones (growth stocks),

$R_{MOM,t}$  is the spread between the returns of past winners (stocks with the highest prior returns) and past losers (stocks with the lowest prior returns).

Equation (1) nests the three-factor model of Fama and French (1993) as the special case where the momentum factor drops out ( $\beta_{MOM}=0$ ). Fama and French (1996) advocate that their three-factor model is the best benchmark model, as it accounts for most of the market anomalies left unexplained by the one factor Sharpe (1964) - Lintner (1965) CAPM. Indeed, following Fama and French (1993) the empirical success of their model allows its interpretation as an equilibrium multifactor model of stock returns, consistent with the arbitrage pricing theory of Ross (1976). In this framework,  $R_{M,t}$ ,  $R_{SMB,t}$  and  $R_{HML,t}$  can be interpreted as three common sources of risk across stocks, namely the market risk of the CAPM ( $R_{M,t}$ ) and two other non-diversifiable risks: a small size risk, captured by  $R_{SMB,t}$ , and a distress risk, captured by  $R_{HML,t}$ . However Fama and French (1996) acknowledge that their three-factor model does not account for the short run persistence of returns or momentum effect put into evidence by Jegadeesh and Titman (1993). Therefore, following Carhart (1997) we use the more general four-factor model.

The sovereign European debt crisis of 2010-2011 has undermined the recovery of European banks from the financial and banking crisis of 2007-2008: the downgrading of sovereign ratings have fuelled the downgrading of banks, the sovereign debt holdings of banks have depreciated as has the implicit sovereign guarantee to banks. The consequences of sovereign risks for the private sector of advanced countries have long been deemed negligible and, as such, have been neglected by the mainstream financial literature on stocks common risk factors. To allow for the specific additional risk entailed by the European sovereign debt crisis we add to equation (1) a European sovereign risk factor  $R_{SOV,t}$ , proxied by the change in the sovereign CDS:

$$R_{p,t} = \alpha + \beta_M R_{M,t} + \beta_{SMB} R_{SMB,t} + \beta_{HML} R_{HML,t} + \beta_{MOM} R_{MOM,t} + \beta_{SOV} R_{SOV,t} + \varepsilon_{p,t} \quad (2)$$

In order to introduce nonlinearities in the model and test for shift contagion (Forbes and Rigobon, 2001), we turn to a STR extension of equation (2) in which the coefficients may change during crisis episodes:

$$R_{p,t} = \alpha^L + \beta_M^L R_{M,t} + \beta_{SMB}^L R_{SMB,t} + \beta_{HML}^L R_{HML,t} + \beta_{MOM}^L R_{MOM,t} + \beta_{SOV}^L R_{SOV,t} + g(v_{t-\tau}; \gamma, c) [\alpha^{NL} + \beta_M^{NL} R_{M,t} + \beta_{SMB}^{NL} R_{SMB,t} + \beta_{HML}^{NL} R_{HML,t} + \beta_{MOM}^{NL} R_{MOM,t} + \beta_{SOV}^{NL} R_{SOV,t}] + \varepsilon_{p,t} \quad (3)$$

Where the transition function  $g(v_{t-\tau}; \gamma, c)$  varies between 0 and 1 as the transition variable  $v_{t-\tau}$  crosses the threshold  $c$ .

As we look for a transition variable  $v_{t-\tau}$  that may represent the financial cycle (Rey, 2013) and crisis episodes in the eurozone we opt for the VSTOXX, the implied volatility of the Eurostoxx50, a eurozone stock market index. In the high volatility regime, when the VSTOXX is above its threshold value  $c$ , we expect that some shifts may affect the coefficients and that they will be captured through the estimated coefficients in the second (nonlinear) part of equation (3).

We study the daily returns on banks stocks from ten European countries –Belgium (BE), Germany (DE), Spain (ES), France (FR), the UK (GB), Greece (GR), Ireland (IE), Italy (IT), the Netherlands (NE), Portugal (PT)- and for purposes of comparison, we extend our analysis to U.S. banks. We consider banks for which both quotation and CDS are available, as their stocks are the most liquid ones and to facilitate comparisons with the related literature. The definition of the data and their sources are detailed in Appendix A2.

As is apparent from Figure 2b, the countries that experienced the highest increases of their Sovereign CDS indices during the European crisis are Greece, Ireland and Portugal (GIP). We therefore calculate an average sovereign CDS index for the GIP countries, using as weights the relative percentages of their governments consolidated gross debts extracted from Eurostat over 2007-2012. We then calculate  $R_{SOV,t}$ , our proxy of the sovereign debt risk in the eurozone simply as the first difference of the logged GIP CDS index.

## Results

We focus our comments on the presence of nonlinearities in our model and on the impact of GIP sovereign risks on banks.

### Nonlinearities in the final estimations

The nonlinear LSTR1 model with the VSTOXX ( $v_{t-\tau}$ ) as a transition variable is supported by the results of the smooth transition regressions (Table 2). With the notable exception of Greek banks returns, whose constant becomes – unsurprisingly - negative in periods of high volatility ( $\alpha^{NL} = -1.13$ ), the constant is not significant in any regime. But all countries experience significant change in the factors coefficients when the European Stock market volatility increases: some shift contagion seems to have been at work during the last crises. The smoothest transitions (low slope parameter  $\gamma$ ) are observed for French banks, while German banks' returns experience the roughest transitions. However, according to the threshold estimate found for Germany (second column and last line of Table 2) the rough transition towards the high volatility regime only affects Germany when the VSTOXX hits record highs equal or above a threshold  $c$  of 60. As is apparent from Figure 1 it only happens for a short time in October and November 2008, in the aftermath of Lehman's bankruptcy filing.



**Table 2:** The linear and nonlinear impact of the European sovereign debt crisis:  
Results of the nonlinear estimations of the multifactor model of bank returns

	<i>BE</i>	<i>DE</i>	<i>ES</i>	<i>FR</i>	<i>GB</i>	<i>GR</i>	<i>IE</i>	<i>IT</i>	<i>NE</i>	<i>PT</i>	<i>U.S.</i>
<i>Linear Parameters</i>											
$\alpha^L$	0.09	-0.07*	-0.04	0.01	-0.01	0.02	-0.22	-0.10	0.01	-0.06	-0.03
$\beta_{SOV}^L$	-0.12***	-0.04***	0.11***	-0.06	-0.04*	-0.28***	-0.04	-0.03	-0.05**	-0.08***	0.02*
<i>Nonlinear Parameters</i>											
$\alpha^{NL}$	-0.27	0.22	0.13	0.28	1.16	-1.14**	0.12	0.26	-0.12	-0.19	-0.20
$\beta_{SOV}^{NL}$	-0.70***	-0.09	0.05*	-0.36*	-0.27	0.17*	-0.47**	-0.21**	-0.36)	-0.08	0.02
<i>Transition Parameters</i>											
$\gamma$	2.51	472	15.6	0.91	1.15	3.35	1.85	1.19	1.53	2.69	5.77
$c$	48.9	59.6	30.9	56.9	63.1	41.6	51.8	43.4	55.8	41.5	40.6

Note: \* denotes significance at 10%, \*\* at 5%, \*\*\* at 1%





#### The linear and nonlinear impact of GIP Sovereign CDSs

The results displayed in Table 2 show that in all the European countries under study banks' returns have at some point been negatively impacted by the rise in the Sovereign CDS of Greece, Ireland and Portugal (GIP). Indeed, either  $\beta_{SOV}^L$  and/or  $\beta_{SOV}^{NL}$  are negative and their sum is always below zero: when the VSTOXX surges above a threshold ( $c$ ) estimated between 30 (for Spain) and 63 (for the UK) European banks stock returns drop in response to a rise in the Sovereign risk of the three countries most adversely hit by the European sovereign debt crisis. This finding is consistent with the results of Chan-Lau et al. (2012) and Grammatikos and Vermeulen (2012) concerning the transmission of Sovereign risks to banks during the period 2008-2011. For Germany this negative impact is slight ( $\beta_{SOV}^L = -0.04$  and  $\beta_{SOV}^{NL} = 0$  cannot be rejected), but nonetheless significant. For some countries, such as Greece or Spain, the negative impact is more sizable ( $|\beta_{SOV}^L|$  being larger) - which may explain why Arnold (2012) mainly captures this effect - though it does not appear to be further strengthened when the VSTOXX increases sharply. But for most European countries the nonlinear effect is dramatic: it is mostly when the VSTOXX rises above its threshold  $c$  that the high risk aversion and the European economic downturn cause banks stock returns to plummet in reaction to a hike in GIP sovereign CDSs. Not surprisingly the Irish banks are amongst the most severely affected, a result again in line with Arnold (2012). But, in line with the conclusions of Bhanot et al. (2014) and Grammatikos and Vermeulen (2012), we find that some contagion appears to spread the negative impact of the GIP Sovereign risks outside the GIP and, in particular, it harshly hits the Belgian, Italian and French banks for which the estimates of  $\beta_{SOV}^{NL}$  are largely negative. These results contrast interestingly with the one found for U.S. banks, which seem to stay mostly unharmed by the direct impact of the European Sovereign debt crisis: at a 10% significance level U.S. banks returns appear even to slightly benefit ( $\beta_{SOV}^L > 0$ ) from the European turmoil through a kind of flight to quality effect.

#### 4. Conclusion

This study provides some empirical evidence on contagion between banks and European sovereigns during the successive episodes of crises of the period 2007-2013, including the recent eurozone sovereign debt crisis. More specifically, we use an explicit multifactor model of banks' equity returns in a nonlinear context to assess to what extent and through which risk factors the European sovereign debt crisis has exerted an influence on banks' equity returns. The use of a variant of the Carhart-Fama-French model allows us to control for the multiple common risk factors other than sovereign risk that may have impacted banks' stock returns over the period. Besides, we capture changes in parameters associated with shift contagion by

estimating a Smooth Transition Regression model. The main advantages of this approach are to allow for an endogenous definition of crisis periods and for smooth transitions between regimes. Our findings suggest that contagion effects have been limited to European banks and that the delay in cleaning up European banks' balance sheets of their distressed assets has put them at a disadvantage relatively to their American counterparts. In addition, if we focus more particularly on the impact of GIP (Greece, Ireland and Portugal) sovereign CDS, we show that contagion effects appear beyond the banks located in these countries, as banks' equity returns from Belgium, France and Italy have been negatively impacted by the sovereign debt crisis. This result contrast with the one found for U.S. banks, which seem to be unharmed by the direct impact of the European Sovereign debt crisis and even to slightly benefit from the European turmoil through a kind of flight to quality effect. In terms of policy implications, our results clearly suggest that a resolution of the sovereign debt crisis is a prerequisite to strengthen the stability of the European banking system. From this standpoint, there is a complementarity between the European banking union project and the implementation of mechanisms allowing the resolution of the sovereign debt crisis at the European level. More particularly, our findings echo the studies stressing the structural changes about the public debt management implied by the creation of the monetary union.<sup>10</sup>

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<sup>10</sup> See, for instance, Pisani-Ferry (2012), De Grauwe and Ji (2013) and Krugman (2013).

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## Appendix

**Table A1:** List of countries and banks

<b>Belgium</b>	KBC Bank
<b>France</b>	BNP Paribas, Crédit Agricole S.A., Natixis, and Société Générale
<b>Germany</b>	Commerzbank, Deutsche Bank, IKB Deutsche Industriebank, Landesbank Berlin Holding, and Landesbank Hessen-Thuringen Giro Genussscheine
<b>Greece</b>	Alpha Bank, Eurobank Ergasias S.A., and National Bank of Greece
<b>Ireland</b>	Allied Irish Banks, Bank of Ireland, and Permanent TSB Group Holdings
<b>Italy</b>	Banca Monte Dei Paschi, Intesa Sanpaolo, Mediobanca, and Unicredit
<b>Netherlands</b>	Aegon and ING
<b>Portugal</b>	Banco Comercial Portugues and Banco Espirito Santo
<b>Spain</b>	Banco De Sabadell, Banco Popular Espanol, Banco Santander, Banco Bilbao Vizcaya Argentaria, and Banco Intercontinental Espanol
<b>United Kingdom</b>	Barclays, HSBC, Lloyds Banking Group, and Standard Chartered
<b>United States</b>	American Express, Bank of America, Bank of New York Mellon, Capital One Financial, Citigroup, Goldman Sachs, Morgan Stanley, and PNC Financial Services

**Table A2:** Data and Sources

VSTO XX	Implied volatility of the Eurostoxx50	Macrobond
$R_{p,t}$	Banks' stock excess returns	Average of the total daily stock returns of the banks of the country minus the 3 months government interest rate The stock returns are extracted from Datastream. The 3 months government interest rates are the 3 months yields of government benchmarks from Macrobond
$R_{M,t}$	Global market factor	Difference between the daily total return of the MSCI, IMI Equity Index and the 3 months US government yield benchmark. Source: Macrobond
$R_{SMB,t}$	Size	<a href="http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/f-f_factors.html">http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/f-f_factors.html</a>
$R_{HML,t}$	Book-to-market	<a href="http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/f-f_factors.html">http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/f-f_factors.html</a>
$R_{MOM,t}$	Momentum factor	<a href="http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_mom_factor_daily.html">http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_mom_factor_daily.html</a> .

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$R_{SOV,t}$	Sovereign debt crisis	Average sovereign CDS index for the GIP countries, using as weights the relative percentages of their governments consolidated gross debts extracted from Eurostat over 2007-2012 5 years eurozone Sovereign senior CDS indices extracted from Datastream
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