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Banks and sovereigns: did adversity bring them closer?

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ABSTRACT

We analyse the stability of the cross-market shock transmission mechanism between banks and sovereign bonds during the Eurozone sovereign debt crisis for crisis-hit periphery countries and Germany. We also examine the shock propagation of banking shocks and sovereign bond shocks between domestic and external markets. Using a Markov-switching framework, we find strong evidence of bilateral contagion between banks and sovereign bonds and also between domestic and external banking sectors. Sovereign bond markets are different. An external shock only produces contagious effects in Greece, who were largely dependent on external aid. For all the others, external shocks lead to decoupling as investors became increasingly discerning in their perception of the debt instruments issued by different Eurozone states.

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1. Introduction

The relationship between banks and sovereign bonds has attracted a great deal of attention following the financial crises that occurred in both the banking industry and Eurozone sovereign bond markets between 2008 and 2011. Indeed, this relationship is likely to come under scrutiny yet again as the global financial system enters another crisis due to the COVID-19 virus of 2019/2020. Terms such as the 'deadly embrace' of Fahri and Tirole (2018), the 'diabolical loop' of Brunnermeier et al. (2016) and 'dangerous liaisons' of Candelon and Palm (2010) reflect the severe financial consequences of a simultaneous decline in both bank and sovereign bond markets. An extensive literature demonstrates how, in times of crisis, a negative spiral may arise between banks and sovereign bonds, with shocks to either adversely affecting the other and exacerbating an already distressed situation. Acharya, Drechsler, and Schnabl (2014) and Mody and Sandri (2012) model an 'Irish-style' crisis where the trigger for the crisis arises from the declining financial state of domestic banks. Government bailouts of these distressed banks, and/or guarantees to their debt holders, result in a transfer of risk from private banks to the sovereign. The repercussion for the sovereign is a reduced ability to borrow at competitive rates, which, in turn, reduces the credibility of its guarantees. Hence, the fortunes of the two sectors become inextricably linked. Indeed, by 2008 net indebtedness of Irish banks to the rest of the world was 60% of Gross Domestic Product (GDP) and, following increased pressure on the banking system, in September of that year the Irish government provided exceptional support in the form of a comprehensive State Guarantee for the liabilities of the Irish domestic banking system (Central Bank of Ireland report, 2010).

A similar negative spiral is identified by Bocola (2016) and Sosa-Padilla (2018) who focus on a 'Greek-style' crisis. The difference is the trigger for the crisis, with the financial distress erupting from declining public finances.[1] Domestic banks become entangled in the crisis through their holdings of domestic sovereign bonds (balance-sheet channel). As these bonds fall in value and often become increasingly illiquid (liquidity channel), the balance sheet of the domestic banking sector contracts, restricting their ability to borrow on external markets and increasing their risk premium (price channel)[2] and, with it, the likelihood of requiring a government

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bailout.[3] Fahri and Tirole (2018) and Cooper and Nikolov (2018) both demonstrate how feedback loops between banks and sovereigns serve to aggravate downturns in either market.

A related, but distinct, literature on the role of contagion in propagating the crisis also grew rapidly following the crisis years. A large volume of papers has focused exclusively on contagion within European sovereign bond markets. The results are mixed and this may be due to a variety of reasons such as methodology used, the time period of the study and the identified source of the shock. Both Arezki, Candelon, and Sy (2011) and Alfonso, Furceri, and Gomes (2012) show that downgrades to sovereign bond credit ratings caused spillovers to the other sovereign bonds of the Eurozone member states. Mink and de Haan (2013) focus solely on Greek shocks and find evidence that the sovereign bond spreads of the other GIIPS countries all react to news emerging from the Greek market. Likewise, Bird and Willett (2017) find that Greek shocks were contagious to other peripheral markets during the crisis. Similarly, Metiu (2012) and Arghyrou and Kontonikas (2012) both find strong evidence of contagion during the early part of the Eurozone crisis, with the former finding contagion emanating from all GIIPS and the latter showing that Greece was the initial source of contagion but that later, all GIIPS contributed to the contagious transmission of shocks. Another group of studies find a limited role for contagion. Both Beirne and Fratzscher (2013) and Claeys and Vašíček (2014) conclude that contagion played a role in shock transmission but only for short, intense periods. Cronin, Flavin, and Sheenan (2016) show that the sources of contagion differed between two distinct periods of the crisis and were not exclusive to peripheral markets. Blatt, Candelon, and Manner (2015) find that Greek bond shocks do not generate contagion for its fellow member states, but its shocks propagate through a change in dynamics. However, shocks originating in Italy, Spain and Portugal are found to be potentially contagious (with immediate effects) to other Eurozone countries. Finally, studies such as Philippas and Siriopoulos (2013) and Pragidis et al. (2015) find no evidence of contagion from Greece to the other Eurozone member states, while Caporin et al. (2013) attribute the transmission of shocks in Eurozone bond markets to interdependencies rather than contagion.

The literature on the role of contagion in the spread on the banking crisis of 2007–2009 similarly attracted a great deal of attention but produced a more conclusive result. In general, studies find evidence of contagion across the global banking sector, irrespective of sample period or methodology (see, Dungey and Gajurel 2015 and Fry-McKibben and Hsiao 2018 for contagion emanating from U.S. banks; Gropp, Lo Duca, and Vesala (2009) for European banks; and Ahrend and Goujard (2015) and Dungey, Flavin, and Lagoa-Varela (2020) for contagion across the global banking sector).

The third strand of this literature examines the presence of contagion between banks and sovereign bonds. De Bruyckere et al. (2013) find evidence of the excess correlation between the two sectors during the crisis, while Allegret, Raymond, and Rharrabti (2017) find evidence of contagious effects from sovereign bonds to the European banking sector. Georgoutsos and Moratis (2017) present evidence of contagion between banks and sovereigns but suggest that the nature of this contagion changed between the global banking crisis of 2007–2009 and the post-2010 Eurozone sovereign debt crisis.

We re-visit the issue of contagion by examining the stability of relationships across market conditions. We test for contagion within sovereign bond markets, within the banking industry, and between banks and sovereign bonds under one unified framework. Furthermore, we distinguish between the source of the shock between domestic and external markets for both banks and bonds, which allows us to capture any changes in the transmission of domestic and global bank shocks as well as domestic and external bond shocks for each country analysed. We focus on the European periphery countries (Greece, Ireland, Italy, Portugal and Spain) that bore the brunt of the financial crisis and also include Germany as a benchmark case. To empirically capture these potential effects, we adopt the methodology of Dungey, Flavin, and Lagoa-Varela (2020) and extend it to a three-regime setting. Changes in asset/market relationships across market conditions are detected as statistically significant differences between regime-dependent impulse response functions.[4] We detect contagion by analysing the contemporaneous cross-market response to a shock. An intensification of the response during a crisis regime relative to a non-crisis regime constitutes contagion (i.e. a stronger immediate response than would have been predicted by the relationship during 'Normal' market conditions), while a weakening of the relationship is labelled as decoupling. No statistically significant change in the relationship across market conditions implies that the shock transmission was simply due to interdependence or pre-existing linkages. Similar definitions are widely used in the extant literature since Forbes and Rigobon (2002) first distinguished between

contagion and interdependence and concentrating on the contemporaneous change is consistent with Kaminsky (2003) in that the shock leads to 'fast and furious' transmission. Non-contemporaneous changes in the propagation of a shock are termed as changes in the dynamics of transmission mechanism, as in Blatt, Candelon, and Manner (2015), and akin to 'spillovers' in the terminology of Kaminsky (2003). Our methodology allows us to detect each of these changes in cross-market relationships.

Our results have a number of interesting features. Firstly, this turbulent period is best modelled in a three-regime setting, with two distinct phases of the crisis. Secondly, during both phases of the crisis, there is strong evidence of contagion within the banking sector with evidence of strong transmission of global shocks to domestic sectors and also of domestic shocks affecting the global industry. Likewise, both global and domestic bank shocks give rise to contagious effects for the sovereign bond markets of the Eurozone periphery countries. Shocks that originate in these sovereign bond markets also illicit stronger responses from their domestic banking sectors during a crisis, though the strong positive response are generally only observed during the intense phase of the crisis. Finally, within the Eurozone sovereign bond markets, we observe a great deal of decoupling, i.e. a weakening of relationships following a shock. Bonds appear to be less responsive to shocks in neighbouring bond markets during the crisis, whether common or country-specific, suggesting that this increased idiosyncratic behaviour could be due to investors differentiating more between the sovereign bonds of these countries, treating them more as heterogeneous rather than homogeneous securities.

The remainder of the paper is organized as follows. Section 2 describes the data, outlines our econometric methodology and discusses our model specification, Section 3 reports and discusses our results. Finally, Section 4 contains our concluding remarks and suggests avenues for future research.

2. Data and econometric methodology

2.1. Data

In this analysis, we use daily banking returns for 13 countries. These are mainly Eurozone countries but we also include the USA, the UK and Japan to capture global banking conditions over our sample. We use Datastream constructed national banking indices for consistency in their construction. We employ returns on a constant maturity 10-year sovereign bond for Greece, Ireland, Italy, Portugal and Spain (GIIPS) to represent sovereign bond market conditions in these crisis-hit countries and we also include Germany as a benchmark, due to its consistently low yield. Once again, these bond indices are constructed by Datastream. Global market conditions are captured through the inclusion of a Datastream-constructed world market portfolio and liquidity conditions are proxied by the TED spread (the difference between the 3-month LIBOR rate and the rate on 3-month U.S. Government Treasury bills), which is soured from the database of the Federal Reserve Board. Our sample covers the period from 1 January 2004 to 31 December 2017. The starting point is chosen to avoid any contamination from earlier crises such as the bursting of the Dot.com bubble, the collapse of the Long Term Capital Management (LTCM) hedge fund or the Latin-American bond crisis.

Table 1 reports summary statistics for the daily log-returns of the banking sectors and for a constant-maturity 10-year sovereign bond of each of the countries analysed.[5]

Turning first to the banking sector, Table 1 reports negative mean returns for all countries apart from Austria, Belgium, France, Spain, Japan and the USA, with Ireland and Greece displaying the highest negative returns. This is unsurprising given the severity of the banking crises experienced in those countries over the sample period. The high volatility of returns indicated by their variances also indicates this. The majority of banking returns are negatively skewed and all experience excess kurtosis, so we reject normality in all cases. The Netherlands stands out in terms of skewness and kurtosis. The Dutch banking system lost approximately €27 million in 2008 (De Nederlandsche Bank 2009, 20) and many large banks active in international markets required assistance, such as ING receiving €10 million on 19th October (Jolly 2008). The Dutch banking index experienced a large drop on 14 October 2008, which coincides with the approval of the debt guarantee scheme in the Netherlands, as well as a lot of volatility in markets, evidenced by the high variance of the series.

Focusing on the sovereign bonds, Table 1 reports small but positive mean returns for all, which is expected for long-term government bonds. The severity of the Greek crisis is indicated by its relatively high variance. Bond

Table 1. Summary statistics.

Banking sector	Observations	Mean	Std deviation	Skewness	Kurtosis
Austria	3651	0.0190	2.1384	−0.1969	5.7506
Belgium	3651	0.0005	2.5044	−0.4836	10.685
France	3651	0.0142	2.2017	0.1428	8.5626
Germany	3651	−0.0183	2.0504	−0.0418	9.909
Greece	3651	−0.1940	3.9230	−0.7777	11.731
Ireland	3651	−0.0793	4.0773	−1.5326	40.684
Italy	3651	−0.0095	2.1673	−0.3851	8.0163
Japan	3651	0.0050	1.7939	0.0272	5.6775
Netherlands	3651	−0.0472	2.9306	−24.073	1050.7
Portugal	3651	−0.0639	2.1932	0.0457	5.3072
Spain	3651	0.0119	1.9512	0.0880	11.034
United Kingdom	3651	−0.0036	1.8442	−0.1790	15.629
United States	3651	0.0106	2.2039	0.1165	19.152
Sovereign Bond	Observations	Mean	Std Deviation	Skewness	Kurtosis
Germany	3651	0.0212	0.3475	−0.1364	2.1849
Greece	3651	0.0169	1.7639	1.1866	96.001
Ireland	3651	0.0238	0.5266	0.5139	32.075
Italy	3651	0.0240	0.0.4722	0.5937	16.570
Portugal	3651	0.0277	0.0.7619	−0.5260	43.036
Spain	3651	0.0244	0.0.4715	0.8982	14.611

Notes: This table reports summary statistics for the daily log returns for the indicated banking sector and sovereign bond. The sample runs from 1 January 2004 to 29 December 2017.

returns in the GIIPS countries are positively skewed (apart from Portugal) and all display high excess kurtosis, thus we reject normality in these cases.

2.2. The econometric methodology

To address the issue of the stability of shock transmission, we employ the methodology of Dungey, Flavin, and Lagoa-Varela (2020), who analyse regime-dependent generalized impulse response functions (GIRFs) to detect if cross-asset responses to a given shock are consistent with market interdependence, contagion or decoupling. In their paper, the empirical application focuses on a two-regime setting but we extend the methodology here to allow for three regimes since there is evidence that the Eurozone sovereign bond crisis is better characterized by different phases rather than a single homogeneous crisis regime, e.g. see Cronin, Flavin, and Sheenan (2016) and Bird and Willett (2017).

Dungey, Flavin, and Lagoa-Varela (2020) propose a Markov-switching factor-augmented VAR (MS-FAVAR) model to analyse the stability of asset market linkages across different market conditions. The factor(s) allow parsimonious representation of a larger system, such as the global banking industry or external Eurozone sovereign bond markets in this application.[6] The econometric model is specified as

$$y_{i,t} = \alpha(s_t) + \sum_{k=1}^{K} \beta_k(s_t) y_{i,t-k} + \epsilon_{i,t}^{st}, \quad s_t \in \{1,2,3\},\ \epsilon_{i,t}^{st} \sim i.i.d.N(0,\sigma_s^2), \tag{1}$$

where $y_{i,t}$ is an n-dimensional time series vector of dependent variables, α is a matrix of state-dependent intercepts, $\beta_1 \cdots \beta_k$ are matrices of the state dependent autoregressive coefficients and capture the relationships between our variables, and $\epsilon_{i,t}^{st}$ is a state dependent noise vector, which has a zero mean and constant variance within each regime. s_t is an unobserved random variable that signals the switch from regime to another. Since the true regime cannot be observed, we must specify the paths by which the regimes transit from one to another. We assume s_t follows a first-order Markov process in which the current regime, s_t relies only on the regime one period in the past, s_{t-1}.

2.3. Our model specification

We seek to model the relationships between the domestic banking sector, the domestic sovereign bond market and the external banking and sovereign bond markets for the crisis-hit GIIPS countries. Due to the intractability of including all potentially relevant external variables, we propose to capture these external effects through the inclusion of two factors; one to capture global banking conditions and the other to capture conditions in the GIIPS sovereign bond markets. It could be argued that the external bond factor could cover more markets but we feel that the greatest turmoil emanated from the sovereign bond markets of the peripheral Eurozone states and there is ample evidence that many investors held long positions in the sovereign bonds of these countries in the immediate run-up to the financial crisis, e.g. see Acharya and Steffen (2015).

Consequently, in our analysis of country *i*, the global banking shock is proxied by a common shock extracted from the banking returns of the other nine (non-domestic) Eurozone countries plus Japan, the UK and the USA. The USA and the UK are included as they both suffered major shocks to their banking industries and contributed significantly to the widespread turmoil experienced by the sector. To capture the shock component of the returns, we first run a standard VAR model of the returns and retrieve the vector of residuals. We then perform a principal component-based factor analysis of the correlation matrix of residuals and use the first principal component as our common external shock. The GIIPS bond factor is extracted in a similar fashion. In the model of country *i*, the bond factor is the first principal component of the sovereign bond return shocks of the GIIPS countries, excluding the country being analysed. The domestic stock and bond return shocks are proxied by the residuals from a first-order VAR with the return on the world market portfolio and the change in the TED spread included as exogenous regressors to control for global market events. Thus, $y_{i,t}$ in our application is a $4x1$ vector of dependent variables comprising of the global bank factor, the domestic bank return, the GIIPS bond factor, and the domestic sovereign bond return. The conditional probability of moving from regime j to i is given by

$$Pr[s_t = j \mid s_{t-1} = i] = p_{ij}. \tag{2}$$

The model is estimated using a Bayesian Markov-chain Monte Carlo (MCMC) approach. We first specify the prior distributions for the parameters. For the variances, we employ a Wishart distribution, the VAR coefficients have a flat prior and we use a weak Dirichlet prior for the transitions, with a preference towards remaining in the same state. Using Gibbs sampling, we estimate the parameters and regimes in the following sequence;

Step 1: We draw the sigmas, given the mean coefficients and regimes.
Step 2: We draw the mean coefficients (α and β) given sigmas and regimes.
Step 3: We draw the regimes, given the sigmas and mean coefficients.
Step 4: We draw the transition parameters.

This sequence of steps is repeated 10,000 times after discarding an initial burn-in set of 2000 replications. Once we have obtained our estimated parameters, we generate the regime-dependent GIRFs and their associated confidence bands. We interpret a statistically significant increase in the response of variable j to a shock to variable i in the crisis regime as contagion from i to j. On the other hand, a statistically significant decrease constitutes decoupling. If the GIRF is unchanged between regimes, this is interdependence.

3. Discussion of results

We estimate the three-regime specification of the model for each of the GIIPS countries, along with Germany as a benchmark case. The regimes are labelled 'Normal', 'Crisis' and 'Intense Crisis'. Figure 1 shows the probabilities for the occurrence of each regime across countries. It is notable that in all countries, 'Normal' market conditions prevailed for the early part of the sample and switched to a sustained period of increased volatility about 2008. From there until the end of the sample, the markets have switched between two crisis phases. The U.S. credit crisis of 2007–2009 sparked a short but intense period of volatility in both Ireland and Spain but had less repercussions for Greece and Portugal. Germany is different from the GIIPS countries. Its more intense phase

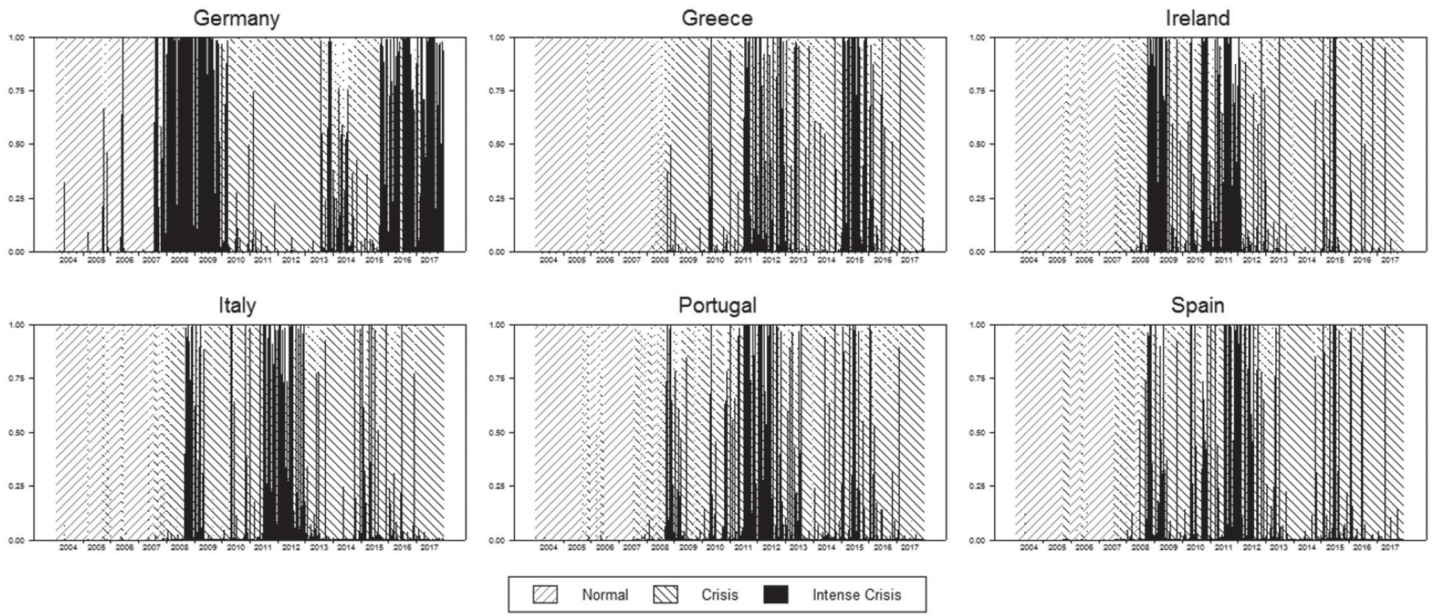

Figure 1. The probabilities for the occurrence of each regime across countries. Diagonal upward sloping (from left) line shading represents the probability that the system is in a 'Normal' market regime, diagonal downward sloping (from left) line shading represents the probability that the system is a 'Crisis' regime and solid black shading represents the probability that they system is in an 'Intense Crisis' regime.

of the crisis coincides with 2007–2009 U.S. credit and subsequent global banking crisis, while the GIIPS all suffer their highest volatility regime later, during 2011–2012 and later again in 2015 when the Eurozone sovereign bond crisis threatened to overwhelm the single currency zone and funding issues came to head, particularly for Greece.

Table 2 presents the main features of each regime. Across the GIIPS, there is a substantial increase in volatility, for both the banking sector and sovereign bonds, as we move from the 'Normal' to the 'Crisis' regime before reaching its highest levels during the 'Intense Crisis'. The increases in volatility between the phases of the crisis is apparent in all the GIIPS countries but is most evident in the banking stocks of Greece and Ireland and in Greek sovereign bonds. Germany is clearly different with a relatively small increase in volatility between the two crisis regimes. The expected returns on banking stocks are never statistically different from zero but typically exhibit a negative sign with the magnitudes of expected losses increasing as we enter the crisis regimes. During the 'Intense Crisis', the Greek banking sector experiences the most negative expected return, which is unsurprising given the trauma its banking system faced over the sample period. Banking stocks in Spain and Ireland appear to be already rebounding during this intense period as their banking sectors had suffered their greatest losses earlier during the U.S. credit and liquidity crisis period. However, these returns remain statistically indistinguishable from zero. Similarly, sovereign bond returns are also not statistically different from zero and their magnitude is relatively small and change little across regimes.

Table 3 presents the transition probabilities and duration measures for each phase of the crisis. Turning first to the transition probabilities, the probability of remaining in the prevailing regime (denoted by P_{NN}, P_{CC} and P_{II})[7] is high across all countries. Upon exiting the 'Normal' regime, there is much higher probability of moving to the 'Crisis' (P_{CN}) rather than the 'Intense Crisis' (P_{IN}) regime. This is consistent with an evolving crisis, with volatility and uncertainty building over time and reaching a crescendo into the relatively-short 'Intense' regime. Once in a crisis, the probability of transiting to a more intense phase is relatively high (P_{IC}), especially for the GIIPS countries and greatly outweighs the probability of exiting the crisis (P_{NC}).

In terms of duration, 'Crisis' regimes tend to last longer than 'Intense' regimes. On average, across the GIIPS, the duration of the 'Crisis' and 'Intense' regimes are about 10 days and 4 days, respectively. For these countries, the crisis phases are short-lived but generate great turbulence in the financial system. The crisis regimes are quite different in Germany. While regimes have a longer duration, it should be noted that the volatility in the German financial system is low relative to the GIIPS countries, particularly in the sovereign bond market. Negative shocks are more persistent in Germany but never produce such intense volatility peaks as experienced in its neighbouring states. For example, in the intense regime, German equity volatility is lower than equity return

Table 2. Regime-dependent expected returns and standard deviations of return.

	Non-crisis regime		Crisis regime		Intense crisis regime	
	μ	σ	μ	σ	μ	σ
Banking sector						
Germany	−0.043	0.739	−0.067	1.355	−0.063	1.981
Greece	−0.027	1.211	−0.222	2.725	−0.610	7.324
Ireland	−0.059	0.977	−0.186	2.227	0.080	7.378
Italy	−0.041	0.753	−0.061	1.433	−0.012	3.022
Portugal	−0.007	0.787	−0.102	1.646	−0.137	3.459
Spain	−0.057	0.714	−0.049	1.190	0.044	2.527
Sovereign Bond						
Germany	0.012	0.247	0.027	0.381	0.019	0.370
Greece	0.018	0.247	0.047	0.706	−0.013	3.874
Ireland	0.014	0.232	0.042	0.290	−0.017	0.986
Italy	0.009	0.241	0.039	0.329	−0.002	0.896
Portugal	0.016	0.245	0.030	0.417	0.031	1.500
Spain	0.018	0.247	0.033	0.346	0.006	0.814

Notes: This table reports the estimated regime-dependent expected returns (μ) and standard deviations of returns (σ) for the equity and sovereign bonds of the indicated country.

Table 3. Transition probabilities and crisis durations.

Country	P_{NN}	P_{CN}	P_{IN}	P_{NC}	P_{CC}	P_{IC}	P_{NI}	P_{CI}	P_{II}	Crisis duration	Intense crisis duration
Germany	0.939	0.009	0.052	0.003	0.965	0.033	0.044	0.031	0.925	25.64	13.70
Greece	0.974	0.023	0.003	0.016	0.892	0.092	0.002	0.257	0.742	9.765	4.277
Ireland	0.965	0.031	0.004	0.015	0.890	0.096	0.002	0.268	0.731	9.090	3.718
Italy	0.966	0.030	0.004	0.014	0.910	0.076	0.002	0.247	0.751	13.34	5.084
Portugal	0.950	0.044	0.006	0.026	0.869	0.106	0.002	0.284	0.714	7.732	3.765
Spain	0.978	0.019	0.003	0.008	0.907	0.085	0.002	0.249	0.749	10.750	3.980

Notes: This table reports the estimated transition probabilities for each country. P_{ij} represents the probability that of being in regime i in the current period given that regime j prevailed in the previous period, $\forall i, j \in \{N, C, I\}$.N, C and I denote the non-crisis, crisis, and intense crisis regimes, respectively.

volatility in all other countries, and even less than the volatility experienced by Greece and Ireland in the first phase of the crisis.

We analyse the transmission of shocks across regimes to ascertain if asset returns behaved in a manner consistent with 'Normal' market conditions during each phase of the crisis (interdependence) or if markets suffered from contagion or became decoupled during the crisis. Figures 2–13 present an overview of our results. Within each figure, results are presented by country by displaying the regime-dependent GIRFs (and associated confidence intervals) generated by the shock under analysis. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where the contemporaneous response is weaker in a crisis relative to a non-crisis regime) or contagion (where the contemporaneous response is stronger in a crisis relative to a non-crisis regime). Changes in the transmission mechanism in subsequent days constitute spillovers.

3.1. Transmission of interbank shocks

We begin by analysing how shocks were transmitted between the global banking industry and the domestic banking sectors of each country. First, we focus on the response of the domestic banking sector following a shock to the global banking sector. Figure 2 presents the regime-dependent GIRFs for the six countries. The first notable feature of the transmission of the global shock is that it only exerts a positive contemporaneous (day 0) impact on the German and Spanish banking sectors during the 'Normal' regime. For Greece, Ireland, Italy and Portugal, the effect is either negative or zero. This probably reflects the relatively small size of these country sectors in the global context. Secondly, there is clear evidence of contagion in both crisis periods. In both crisis regimes, the response of the domestic banking sector is always positive (i.e. they move in the same direction), implying that domestic banks were adversely affected by external developments in the sector and declined by more than could have been anticipated from pre-crisis linkages. Furthermore, the contagion effect increases as the crisis intensifies in Germany, Greece and Ireland. There is limited evidence of spillovers (changes in dynamics) for this relationship with Italy providing the most evidence of such a phenomenon. The short-lived nature of the shocks in all regimes allows little time for spillovers to occur.

We also look at the potential feedback effects by studying the impact on the global banking industry of shocks originating in the domestic banking sectors of each country. Figure 3 presents the relevant GIRFs. Once more, the 'Normal' regime suggests that the smaller markets are not overly influential in the global banking industry. Shocks to the Greek, Irish, Italian and Portuguese banking sectors transmit little or nothing to the global factor, while Spanish shocks result in positive comovement with the global factor. The pattern is markedly different in both phases of the crisis, with evidence of contagion from domestic markets to the global industry. However, only Irish and German shocks exhibit a significantly different transmission between the two phases of the crisis. Irish shocks generate most contagion during the first phase of the crisis, during which the Irish banking sector was on the brink of extinction – two of the six indigenous banks became insolvent during this period resulting in their nationalization and subsequent wind-up, while the four that survived required significant capital injections from the domestic government (see Connor, Flavin, and O'Kelly 2012, for a detailed review of the Irish banking crisis). This increased transmission suggests that the heightened sensitivity of the distressed global

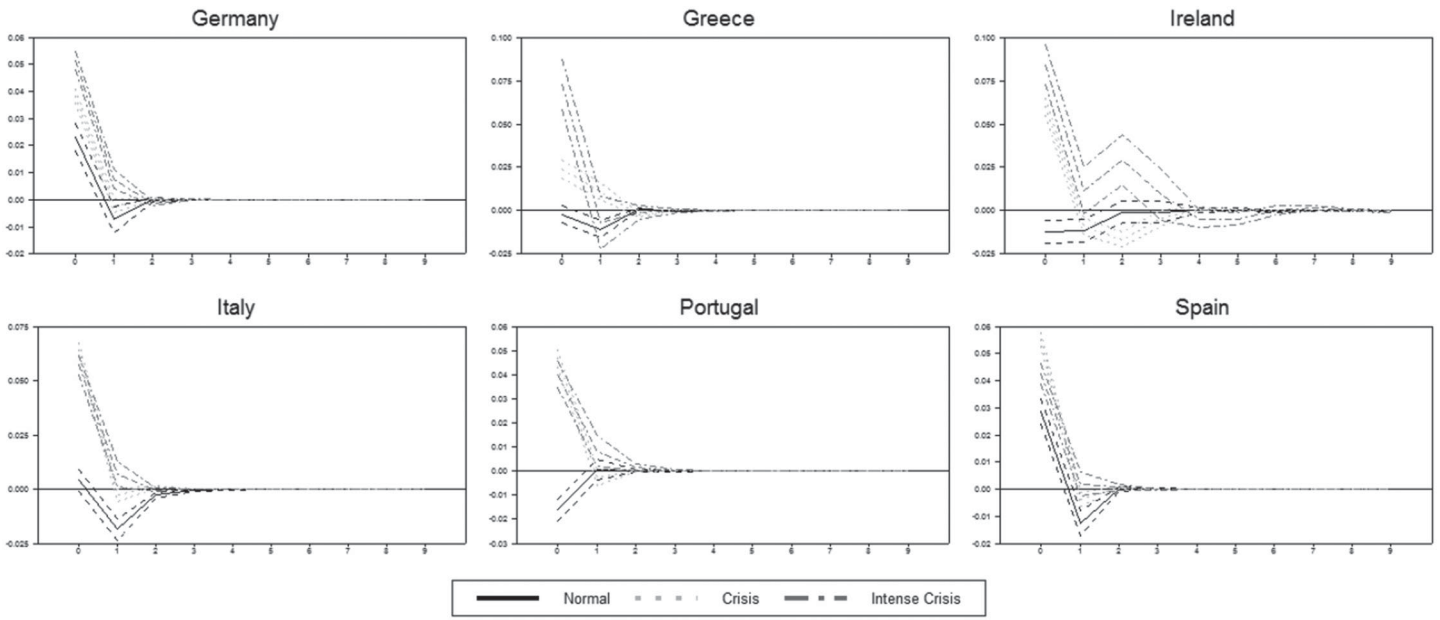

Figure 2. The response of domestic banks to a global banking shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

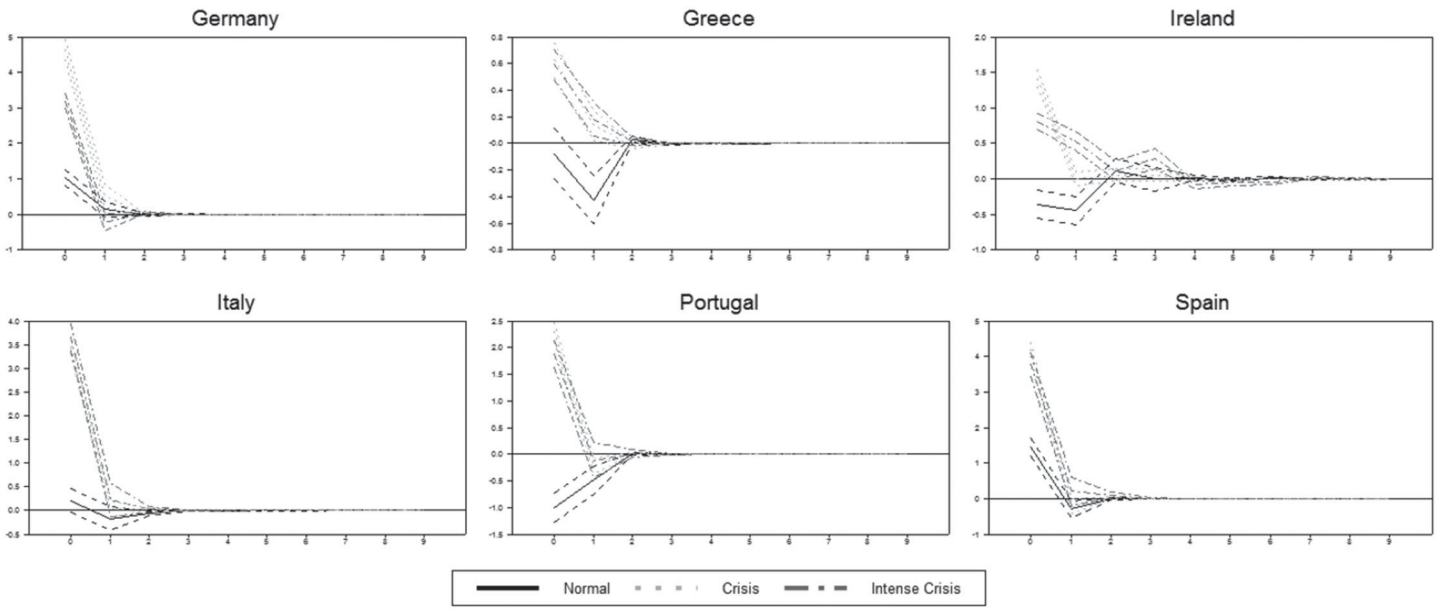

Figure 3. The response of the global banking sector to a domestic banking shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

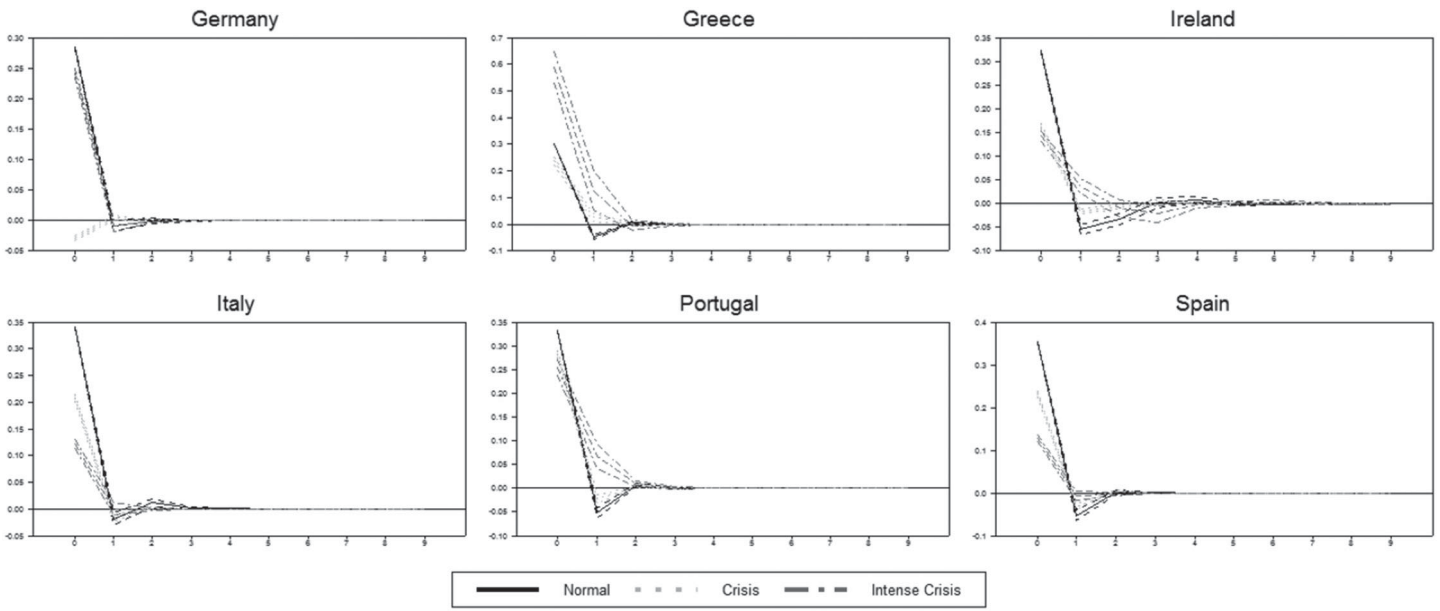

Figure 4. The response of the domestic sovereign bond market to an external GIIPS bond shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

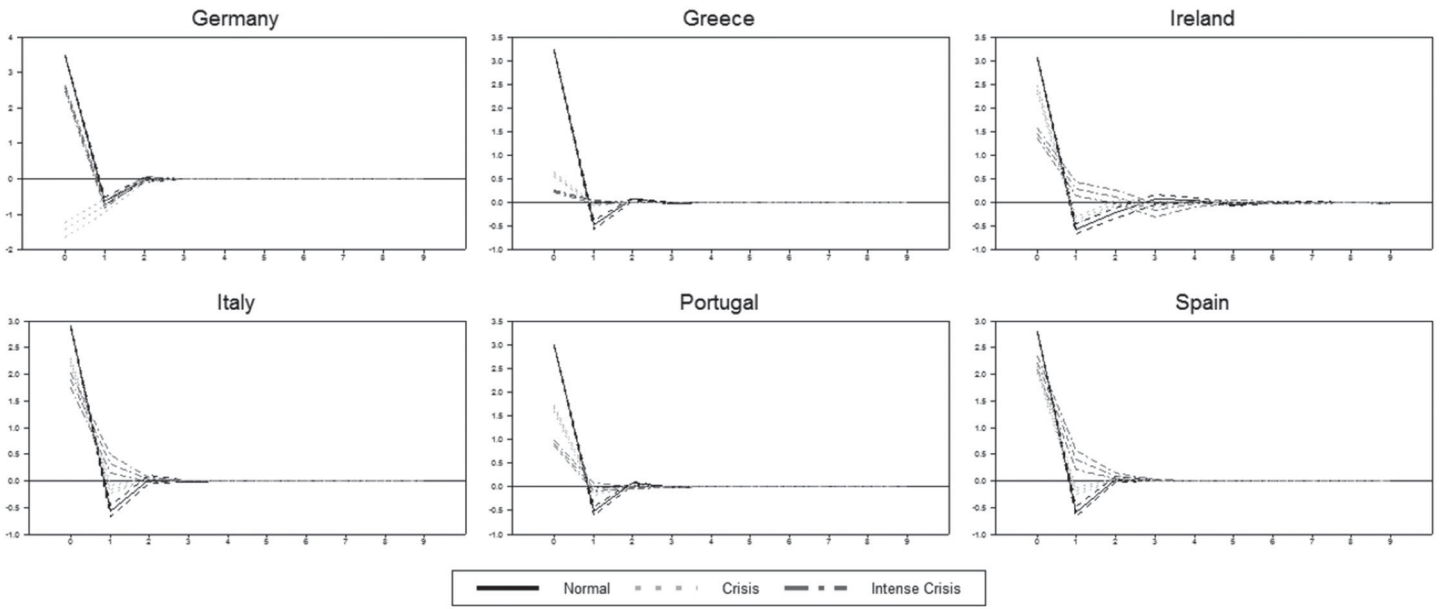

Figure 5. The response of GIIPS bonds to a domestic sovereign bond shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

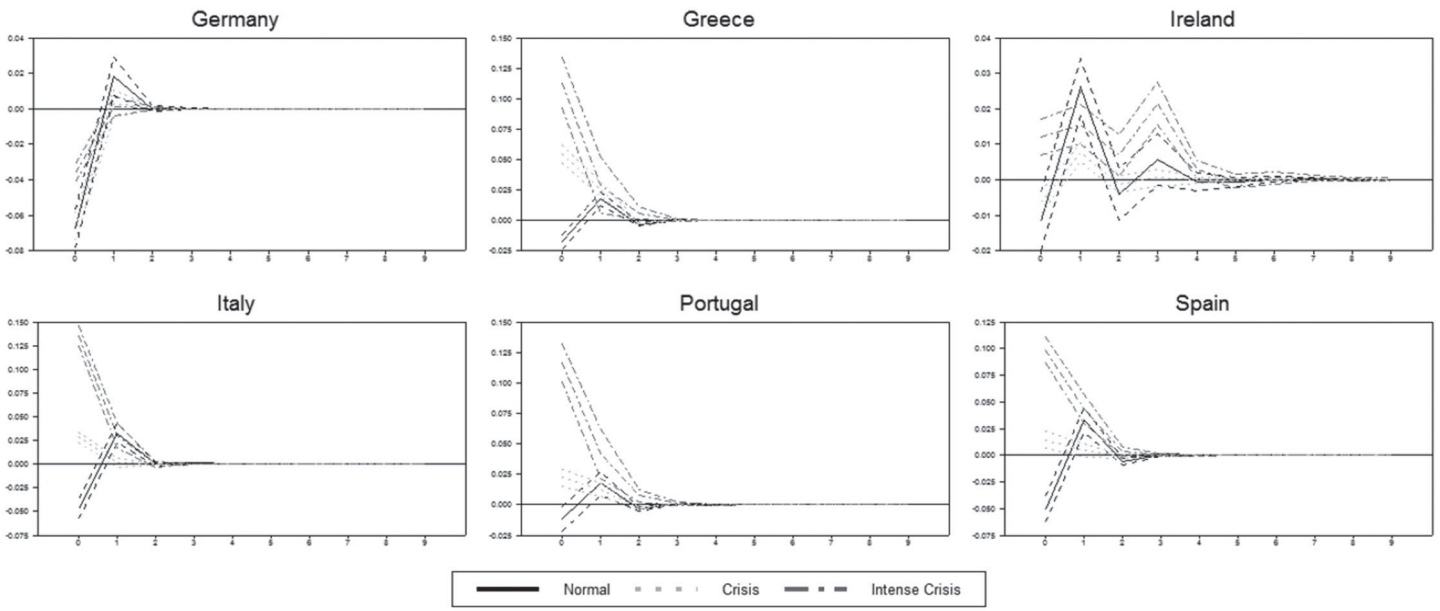

Figure 6. The response of domestic sovereign bonds to a domestic banking shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

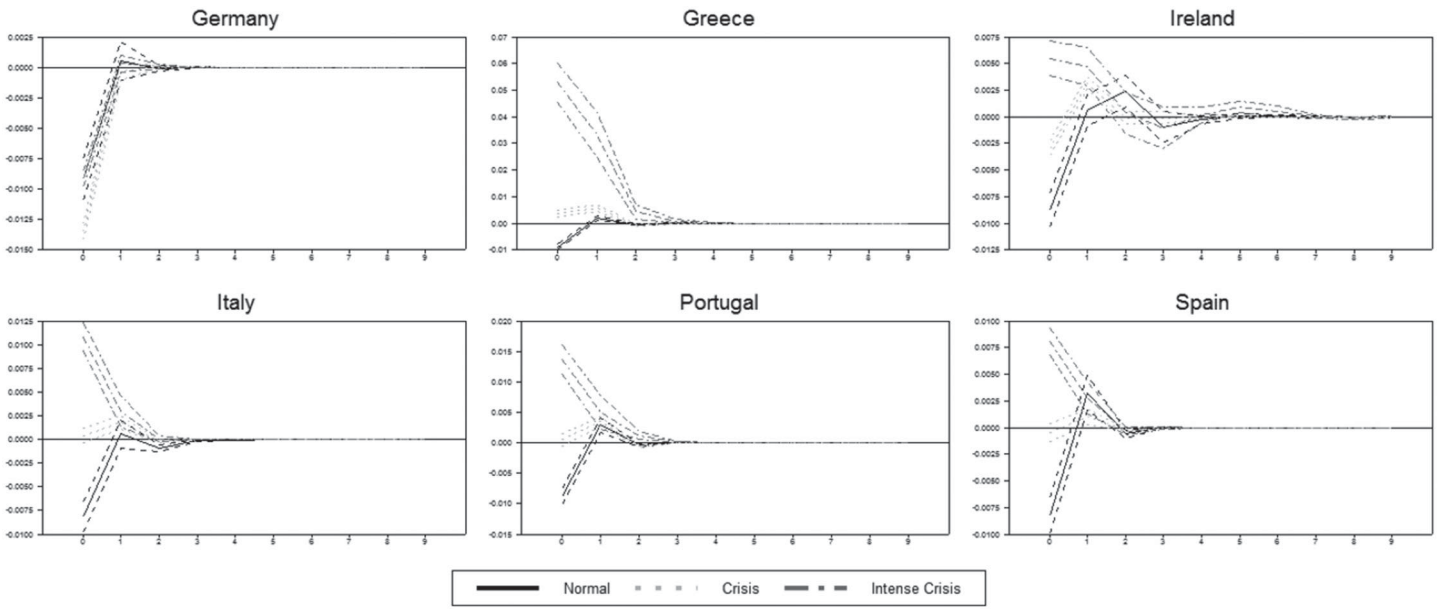

Figure 7. The response of domestic sovereign bonds to a global banking shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

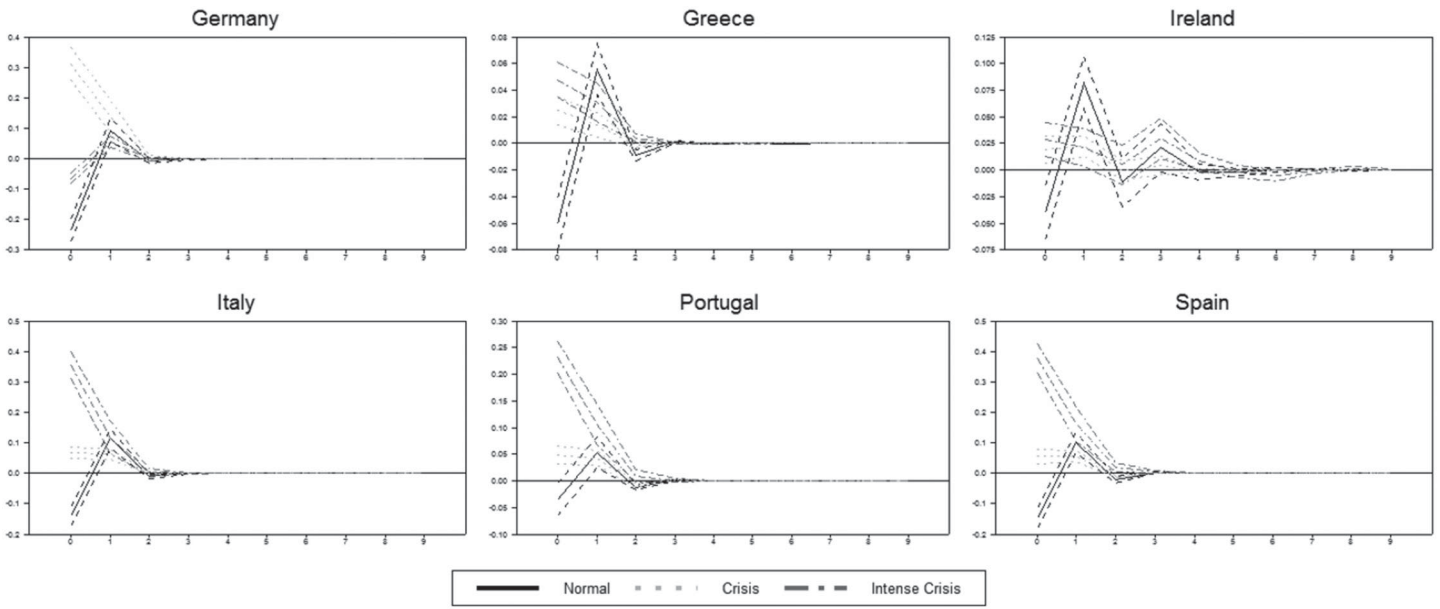

Figure 8. The response of GIIPS bonds to a domestic banking shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

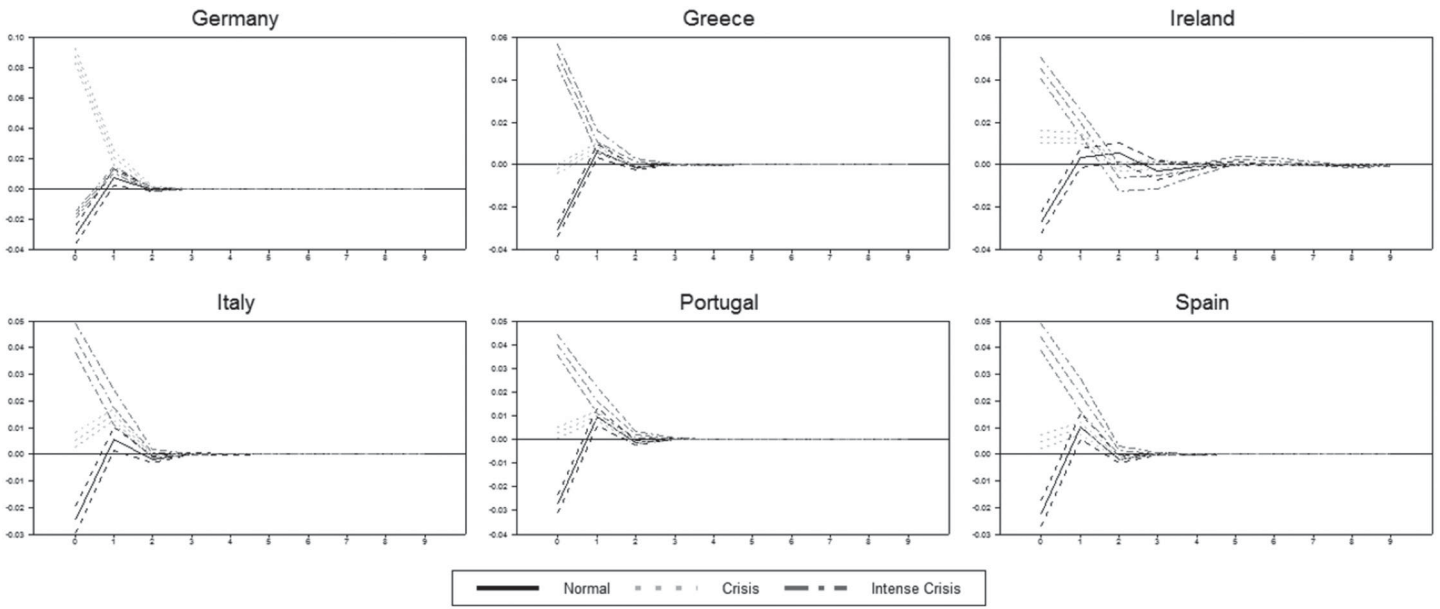

Figure 9. The response of GIIPS bonds to a global banking shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

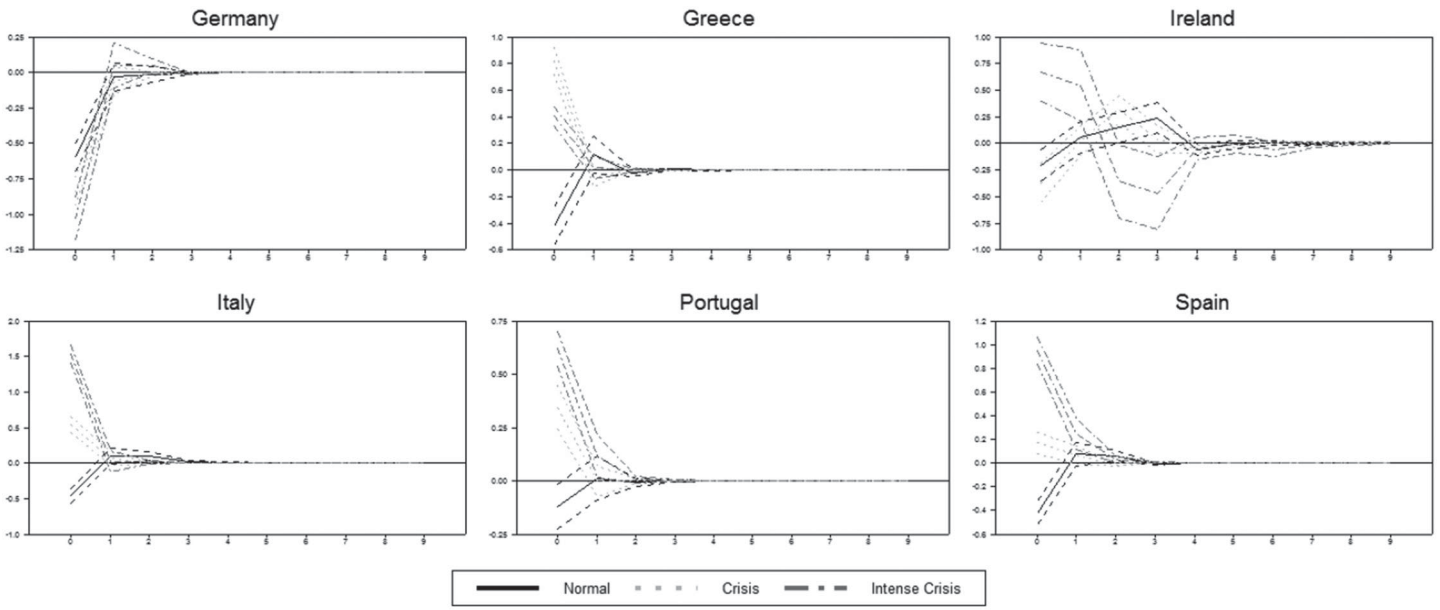

Figure 10. The response of domestic banks to a sovereign bond shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

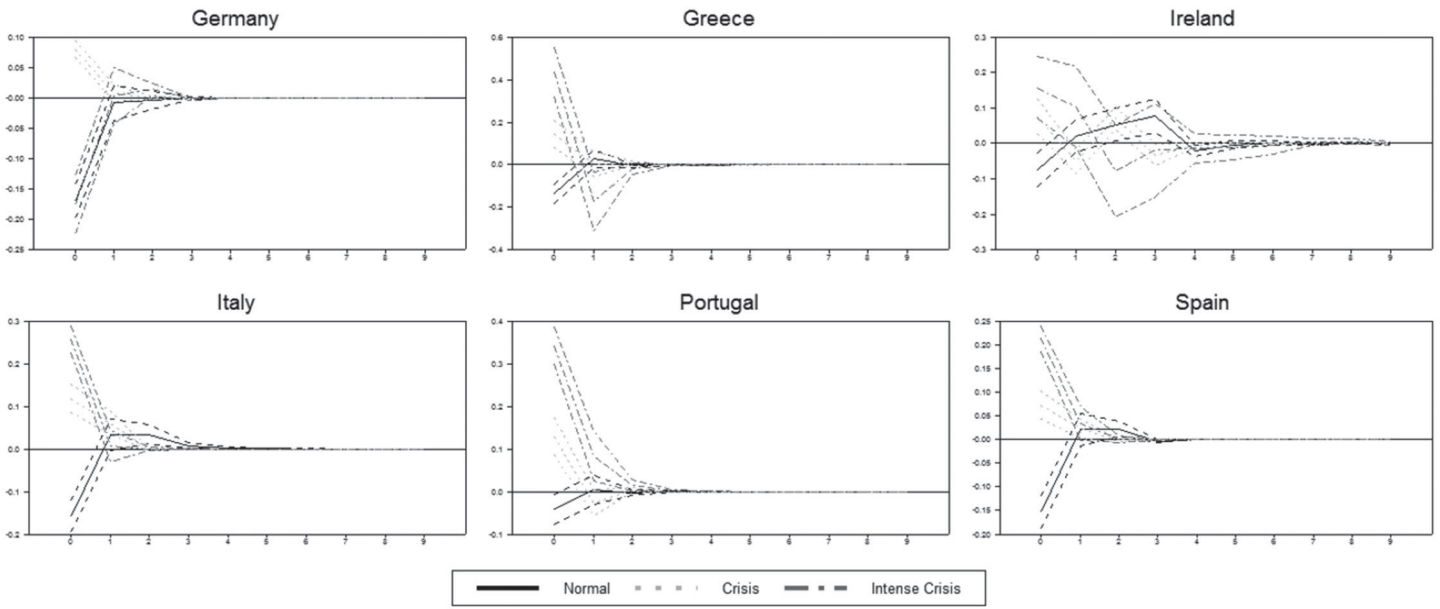

Figure 11. The response of domestic banks to a GIIPS bond shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

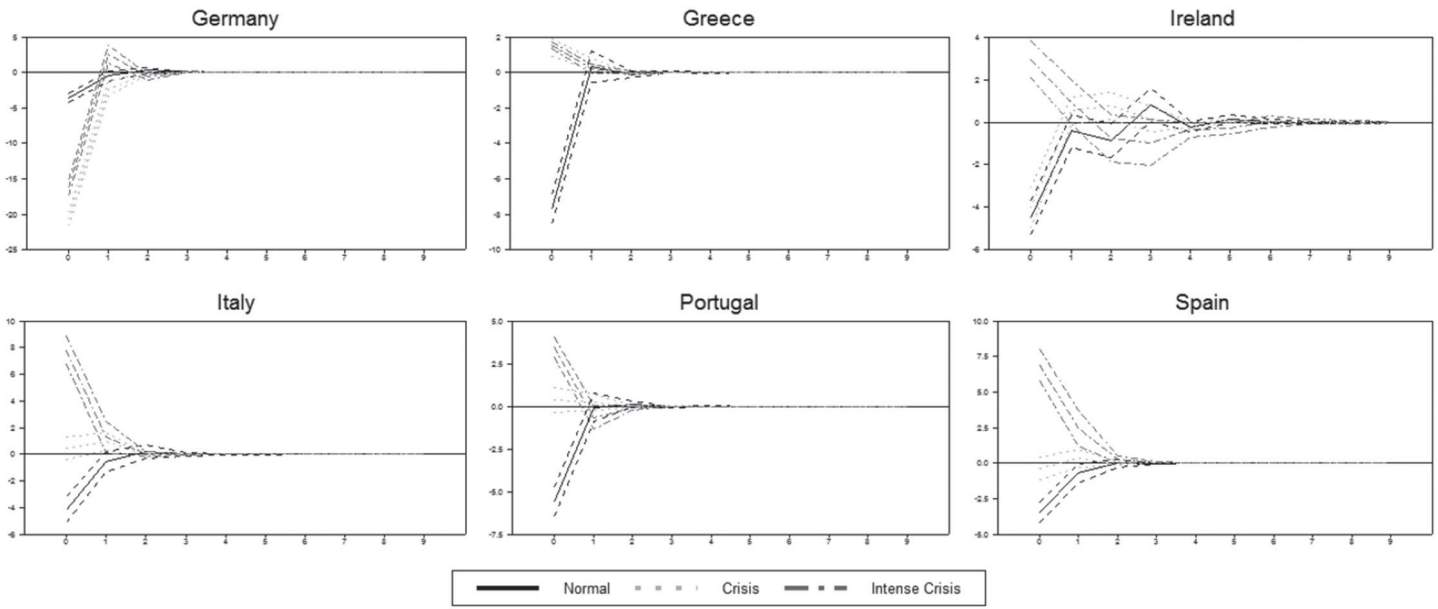

Figure 12. The response of the global banking sector to a domestic sovereign bond shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

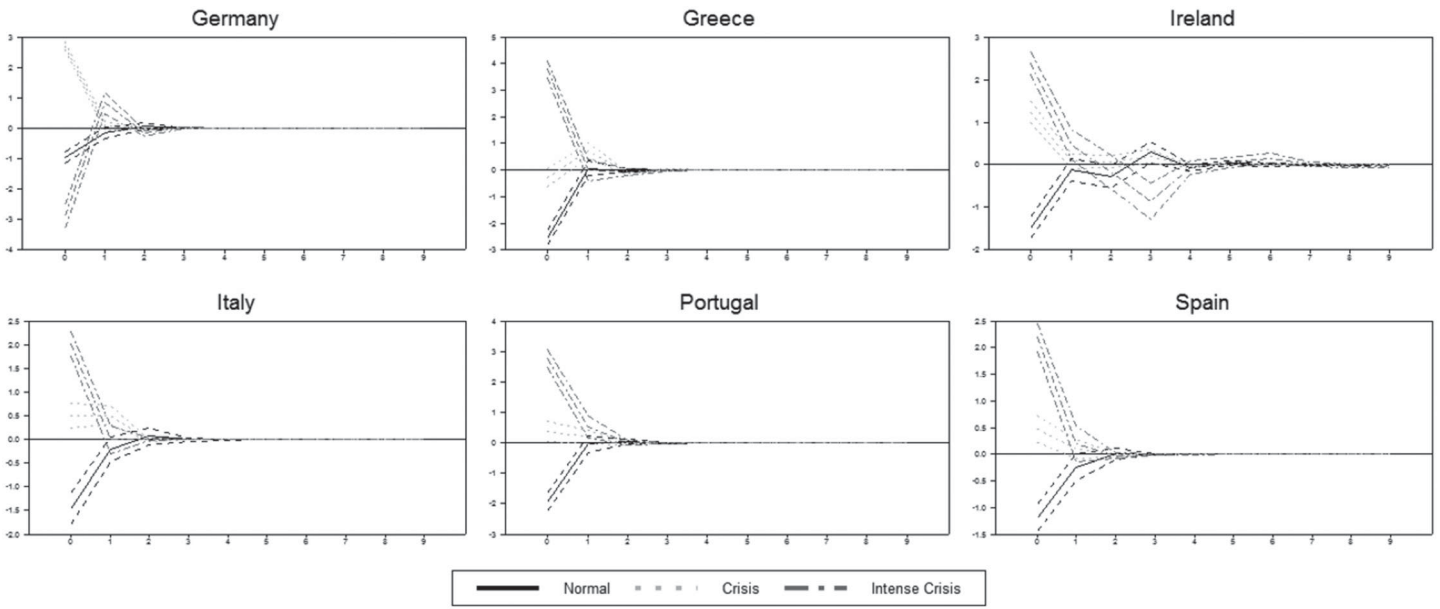

Figure 13. The response of the global banking sector to a GIIPS bond shock across countries. The solid black, dashed grey and dotted dark grey lines represent regime-specific GIRFs for the 'Normal', 'Crisis' and 'Intense Crisis' regimes, respectively. The middle lines depict the IRF with the outer lines showing the 95% confidence intervals. If the confidence intervals overlap, that represents 'interdependence', while if there is no overlap, this signifies either decoupling (where response is weaker in a crisis relative to a non-crisis regime) or contagion (where the response is stronger in a crisis relative to a non-crisis regime).

banking sector during this period resulted in larger than expected responses to adverse shocks originating in relatively small, and previously relatively unimportant, markets like Ireland. Germany, on the other hand, transmits stronger contagion during the later period of the crisis, coinciding with the Eurozone sovereign debt crisis. During this phase, the exposure of German banks to credit risk in the sovereign bonds of the Eurozone periphery made them more vulnerable and hence an increased risk factor for the global sector. We also observe a change in the dynamics of shock transmission for Greece and Ireland with more persistence, generating spillovers in the day following the original shock.

3.2. Transmission of intra-bond market shocks

Next, we turn our attention to the sovereign bond markets and, in particular, the stability of the propagation of cross-country shocks. First, we look at how a shock to the other GIIPS bond market affects the domestic bond markets of each country, with the relevant GIRFs presented in Figure 4. During 'Normal' market conditions, there is a strong positive response to a bond shock originating in the other peripheral bond markets. This shows that in these tranquil times, all Eurozone bonds behaved in a similar fashion and were perceived to be close substitutes by investors (see Acharya and Steffen 2015). However, as markets transit to the crisis phase, we observe decoupling across the board and it is most apparent in Spain and Italy. This suggests that investors began to differentiate more between bonds. The most interesting aspect of this set of GIRFs is the reaction during the latter phase of the crisis, which is the intense phase for the GIIPS and crisis phase for Germany. Firstly, German sovereign bonds completely decouple from the GIIPS bond shock and exhibit a negative response to shocks in the Eurozone periphery. This is consistent with German being perceived as a safe haven for Eurozone investors and investors diverting funds from the Eurozone periphery to German government instruments. At the other extreme, Greece in its state of financial chaos suffers contagion. Any negative news emanating from bond markets of the other GIIPS exacerbated the Greek turmoil, possibly due to its heavy reliance on its Eurozone partners for bailout assistance. In the smaller of the remaining countries, Ireland and Portugal show no statistical difference in their responses between the two phases of the crisis, i.e. they remain decoupled relative to normal times, though there is evidence of stronger spillovers in Portugal during the intense phase. Finally, Spanish and Italian sovereign bonds become increasingly decoupled (even though the response remains positive), suggesting that investors perceived these bonds to be of higher-credit quality or, at least, that they were less likely to default than the bonds of other smaller peripheral states.[8]

Figure 5 examines how a shock in country *i* is transmitted to the other GIIPS bond markets. Consistent with Figure 4, there is a strong positive response while 'Normal' market conditions prevail and strong evidence of decoupling during the crisis regimes. Again, Germany is different and the negative response during the latter phase of the crisis reinforces the idea that Germany acted as a safe haven for bond investors. Among the GIIPS, there is decoupling during both phases of the crisis and the extent of decoupling depicts a definite ordering on the importance of domestic shocks for the rest of the Eurozone periphery. Spanish and Italian shocks display the least levels of decoupling or alternatively, shocks originating in these countries continued to have a relatively strong influence on the bond returns of the other GIIPS. At the other extreme, Greek bond shocks had little effect on the sovereign bonds of its Eurozone partners as Greece became increasingly isolated from the rest. In the middle, there is Ireland, followed by Portugal, whose shocks continued to exert some influence of the other markets but it continued to decline as the crisis intensified. Once more, evidence of spillovers are limited to a single day with all the GIIPS countries generating increased persistence for neighbouring markets.

3.3. Transmission of shocks across markets

The cross-market transmission of shocks is analysed by studying how banking and bond market shocks affect each other across regimes. There is little or no evidence of spillovers in the cross-market shocks so we concentrate on the contemporaneous effects. We begin by focusing on the propagation of banking shocks.

3.3.1. Impact of banking shocks on sovereign bond markets

Figures 6 and 7 show the GIRFs for the reaction of each country's domestic bond in response to a domestic and global banking shock, respectively. There is a similar pattern across both figures. Firstly, during 'Normal' market conditions, both domestic and global banking shocks illicit a negative or zero contemporaneous reaction in sovereign bond markets. This is consistent with the literature on stock-sovereign bond correlations, which shows that these two asset classes tend to be negatively correlated when financial markets are calm (see Connolly, Stivers, and Sun 2005; Guidolin and Timmermann 2006; Anderson, Krylova, and Vähämaa 2008; Flavin, Morley, and Panopoulou 2014 among others). As we transit into the crisis regime, there is evidence of contagion from the domestic bank shocks across the GIIPS countries but the response remains relatively muted. In the case of the global bank shock, though the response is statistically different from the normal regime and hence by strict definition, constitutes contagion, it is noteworthy that in all cases except Greece the response remains negative or zero. Thus the sovereign bonds remain largely insulated from the direct effects of global banking shocks and continued to provide a hedge against global bank shocks, even if not against domestic bank shocks, during this phase of the crisis. However, in the intense phase of the crisis, the story is strikingly different with strong evidence of contagion in the transmission of both domestic and global banking shocks to the sovereign bond markets across the group of GIIPS. Distress in the domestic and global banking sectors is transmitted to the sovereign bond, contributing to the negative spiral for these pair of markets.

In both phases of the crisis, German bonds behave differently from those of the Eurozone periphery. In fact, the response to both domestic and global banking shocks is consistently negative across all market conditions. The response to domestic banking shocks becomes slightly less negative for the intense phase of the crisis, which strictly speaking meets our definition of contagion, but in a more holistic sense what we see is that German sovereign bonds provide diversification benefits for investors in domestic banking stocks.

Figures 8 and 9 depict the response of the GIIPS bond factor (the common reaction across the non-domestic bonds) to domestic and global banking shocks, respectively. There is a very similar pattern across both Figures so we examine the reactions together. Consistent with the negative comovement exhibited by equity and bond returns during normal time periods, the contemporaneous response of the GIIPS bond factor is always negative or zero to a country-specific bank shock.

This relationship is reversed during both phases of the crisis for all GIIPS countries. Contagion is a feature of the propagation of the domestic bank shock to the bonds of other peripheral countries, illustrating the adverse knock-on effects of problems in the domestic banking sector. This pattern of contagion from banking shocks to sovereign bond markets is consistent with the analysis of Merton et al. (2013) who highlight the role of government guarantees of banks' assets in creating an environment where contagion may occur. They argue that government guarantees, either implicit or explicit, are akin to a situation where private banks hold a put option written by the sovereign on bank assets. This lies dormant in 'Normal' market conditions but is exercised by banks against the sovereign during crisis periods, creating problems in accessing sovereign bond markets. Laeven and Valencia (2013) provide estimates of the financial cost of the banking crises in these and other Eurozone states as domestic governments implemented a range of resolution programmes to prevent the failure of these private banks. These resolution programmes, in effect, transferred private debts to the sovereign and these resulted in an adverse transmission to other countries who were affected by the weakening of the common currency and doubts about its ability to withstand the crisis.

Germany is again different. During the first phase of the crisis, 2007–2009, there is evidence of contagion as German banks weakened and thereby restricting the supply of private credit for some Eurozone sovereign bonds from an important debtor. While there is still evidence of contagion during the latter regime of the crisis (i.e. the transmission intensifies relative to the 'normal' regime), the comovement remains negative.

3.3.2. Impact of bond market shocks on banks

Finally, we focus on the stability of the transmission of bond market shocks to the banking industry. Figures 10 and 11 convey the responses of the domestic banking sector to domestic and external GIIPS sovereign bond shocks, respectively. The pattern that emerges reinforces the earlier analysis of cross-market shocks. Banks respond to a domestic sovereign bond shock with a contemporaneous negative reaction during normal regimes, again showing the hedging potential of equities and sovereign bonds during relatively tranquil episodes (Figure

10). The transition to the initial phase of the crisis results in contagion for most of the GIIPS, except in Ireland where this regime sees no change to market linkages, i.e. interdependence. There is strong evidence of contagion in Greece, where a shock to the domestic bond generated a large contagious effect for the domestic banking sector. During the intense crisis episode (which largely coincides with the Eurozone sovereign debt crisis), contagion is rife as weakening domestic bonds hit the balance sheets of domestic banks and eroded the ability of the sovereign to credibly guarantee the liabilities of the banking industry. Interestingly, in the case of Greece, the contagion effects from a domestic bond shock is actually reduced during this regime, possibly due to the fact that the initial crisis had already caused banks to become so badly impaired that their operations were very restricted.

Once more, Germany merits separate analysis. Domestic sovereign bond shocks always illicit a negatively signed contemporaneous response from domestic banks regardless of the prevailing market condition.

Figure 11 shows that domestic banks largely respond in a similar manner to external GIIPS bond shocks. The most notable exception is that of contagion to German banks during the sovereign debt crisis, thereby resulting in evidence of contagion from the sovereign bonds of the Eurozone periphery to all countries during this period. The importance of this transmission channel can most likely be attributed to the exposure of domestic banks to the sovereign bonds of the Eurozone periphery, a phenomenon labelled the 'greatest carry trade ever' by Acharya and Steffen (2015).

Lastly, we look at the reactions across market conditions of the global banking industry to shocks to domestic bonds (Figure 12) and the GIIPS bond factor (Figure 13). Global banks behave like their domestic counterparts in response to a domestic bond shock. There is a negative reaction to a German bond shock across all market conditions, while the shocks in the GIIPS countries lead to a negative response during normal market conditions, have little effect during the first phase of the crisis but propagate contagious effects to the global banking industry during the latter regime which coincides with the sovereign debt crisis. This contagion may be due, at least in part, to fears about the sustainability of the Eurozone project itself.

The common shocks of the GIIPS result in a similar pattern (Figure 13), albeit with a little more sensitivity to the common, non-domestic component of the shock to the bonds of the GIIPS countries. We find evidence of contagion to German banks during the Eurozone sovereign debt crisis as banks feared the imposition of haircuts as part of resolution packages being implemented in Greece particularly. Across the GIIPS, we see an increasing transmission as the crisis intensifies, generating a contagious effect for the global banking industry across all phases of the crisis.

4. Conclusions

This analysis examines the stability of shock transmission across market conditions. We focus on the relationship between banks and sovereign bonds to see whether linkages that pre-dated the financial crisis could explain the comovement during the period of turbulence. We examine shocks that originate in both the banking industry and sovereign bond markets and distinguish between country-specific and external common shocks. We find that market conditions are best captured by three distinct regimes, implying two distinct phases of the crisis. All the GIIPS countries exhibit a similar pattern, with an initial 'Crisis' regime developing into a shorter, more-intense period of turbulence. Our main findings on shock transmission are that pre-existing linkages cannot explain market responses to shocks and that contagion played a significant role in the propagation of the crisis within and across the two sectors of the financial system analysed here. We provide empirical support for the models of bilateral feedback between banks and sovereigns and conclude that adversity did bring them closer, though in an undesirable way. However, we also find evidence of decoupling within sovereign bond markets. Pre-crisis, it appears that investors viewed Eurozone bonds as homogeneous instruments but this breaks down during the crisis as bonds behave and perform differently. An interesting hierarchy of investors perception on credit-worthiness is revealed. At one extreme, German sovereign bonds completely decouple from those of its neighbours in the Eurozone periphery. It exhibits negative comovement and thus appears to be a safe haven for investors within Europe. But even within the GIIPS, there is an interesting pattern of decoupling. Greek bonds exert no influence on the other crisis-hit countries but are more sensitive to news emanating from other markets. Spanish and Italian sovereign bonds also decouple but remain idiosyncratic than the bonds of the

smaller countries, probably due to the European Central Bank's commitment to save the Euro currency and to support the larger crisis-hit countries through bond purchases.

Overall, we find that the Eurozone sovereign debt crisis was exacerbated by financial contagion between banks and sovereign debt markets. The crisis was not due to just the magnitude of the shocks but it was also propagated across markets by an intensification of the shock transmission. Hence these results provide empirical support for proponents of mechanisms designed to break these downward spirals and, in particular, the necessity of the state to bailout private domestic banks. Domestic banks should also better diversify their bond holdings and avoid being overly exposed to domestic sovereign bonds as their diversification benefits are likely to be reduced during a financial crisis. Finally, the ECB intervention to avoid explicit bailouts in Spain and Italy appear to have been, at least partially, successful with the bonds of those countries retaining more investor confidence that bonds of smaller countries whose unsustainable fiscal positions had forced them into explicit bailout programmes before the ECB launched its policy of bond purchase.

As a response to the European banking crisis, the EU has already moved to strengthen bank resilience and increase supervisory powers to mitigate the risk of the necessity of further state bailouts of domestic banks. These policies may help to break, or at least reduce, the 'deadly embrace' of sovereigns and banks. Nevertheless, our empirical findings should serve as a warning to all countries that there is the potential for bi-directional reinforcing effects between financial intermediaries and national fiscal authorities which can quickly produce a negative spiral when one or other suffers a large adverse shock. Extending the analysis to emerging markets, many of which have weaker financial institutions and lower sovereign credit ratings, would allow us to assess the robustness of financial linkages in these countries during the recent financial downturn triggered by the Covid-19 health pandemic. Contagion is a potentially huge threat to financial and economic stability in countries which rely on capital inflows.

More generally, this methodology opens up future avenues of research in financial market linkages. While the European sovereign debt crisis appears to have been brought under control, burgeoning corporate debt appears now to be a greater potential threat to the global banking system (see IMF 2019) and, as we have shown here, may put national fiscal authorities under pressure to save their domestic banks.

Notes

1. For example, the Greek government debt was 172% of GDP in 2011.
2. Albertazzi et al. (2014) discuss the three channels through which sovereign bond shocks may propagate to domestic banks and present empirical evidence consistent with these types of transmission for the Italian economy.
3. In a related literature, though not exclusive to a crisis period, Acharya and Rajan (2013) and Gennaioli, Martin, and Rossi (2014) both highlight the interdependence between sovereign bond markets and the domestic banking sector and show that governments strive to avoid defaulting on its debt due to the adverse effect it would have on the domestic financial sector.
4. Ehrmann, Ellison, and Valla (2003) introduce the concept of regime-dependent impulse response functions.
5. The Datastream mnemonic for the banking sector indices and sovereign bond indices are BANKS+CC and BM10Y+CC, respectively, where CC is a country code.
6. Bernanke, Boivin, and Eliasz (2005) originally introduced the FAVAR to reduce the dimensionality of monetary policy models; while the methodology has also been applied in finance by Claeys and Vašíček (2014).
7. N, C and I represent the Normal (non-crisis), Crisis, and Intense crisis, respectively. In general, P_{ij} denotes the probability of transiting to regime i given that we are currently in regime j.
8. Among the GIIPS, Italy and Spain benefited greatly from the European Central Bank's (ECB) asset purchase programmes. For example, as of December 2012, nearly half of all the outstanding bonds purchased under the Securities Market Programme (SMP) were Italian bonds. For more details, see European Central Bank Press Release 21 February 2013.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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