Bank-Insurance Risk Spillovers: Evidence from Europe

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We investigate cross-sector financial contagion over the period 2006–2014 for a sample of large European banks and insurers. We use CDS spreads and define contagion as correlation over and above what is explained by fundamental factors. Moreover, we assess the impact of different business models on contagion and the channels through which it spreads. We find that, for insurers, size and investment income raise contagion, while for banks capital adequacy, funding and income diversification are the most relevant factors. Furthermore, leverage is crucial in both sectors. We also provide evidence of the main risk transmission channels: the asset-holding and the guarantee channel for insurers and the additional collateral channel for banks. Our results offer new insight on how credit risk spillovers spread across sectors and call for further regulatory and supervisory effort in understanding if and where cross-industry similarities increase contagion risks.
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Introduction

Large and complex financial institutions play a crucial role in propagating systemic risks during financial crisis. Regulators, supervisors, policymakers and researchers, with the aim of prompting financial stability, dedicated considerable attention in understanding activities and risk exposures of banks and insurers. The definition of systemically important financial institutions and the debate on cross-sector similarities and differences emerged to cope with moral hazard incentives stemming from expected government bailouts. In particular, non-core or unregulated activities and the interconnectedness of financial institutions question how risk spreads across firms and sectors.

An example of such interdependence is depicted in Figure 1, showing CDS spreads of a sample of European banks and insurers. CDS are contracts granting indemnity to purchasers in case the underlying entity fails and does not fulfil its obligations towards creditors. As such, CDS prices reflect default probabilities and their spreads signal differences in creditworthiness of institutions. The cross-sector link varies over time and

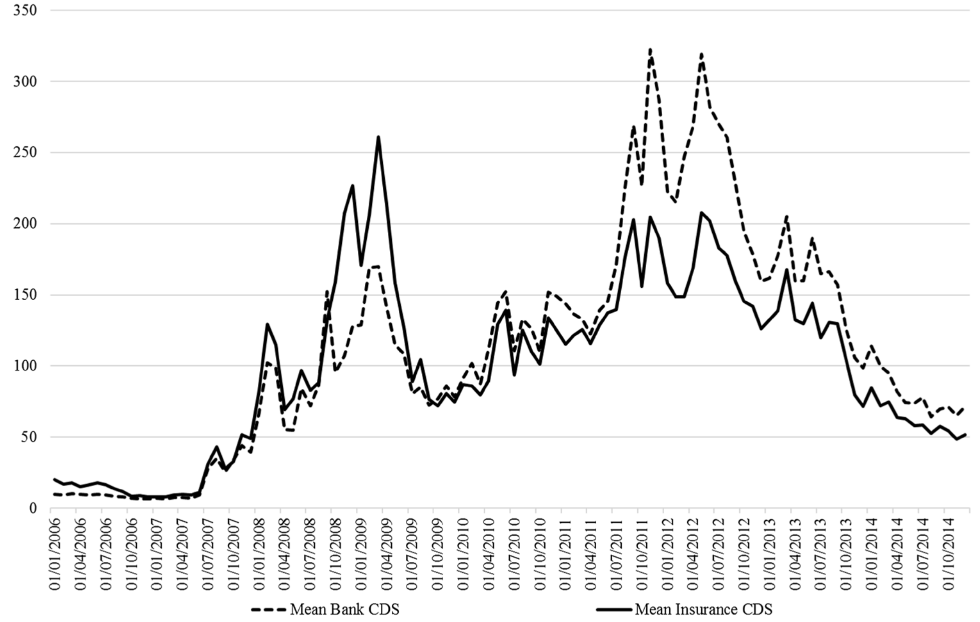

Figure 1. Banks and insurers mean CDS spreads. This figure shows the evolution of mean CDS spreads of banks and insurers in our sample, for the period 2006–2014.

appears to be influenced by economic and banking shocks: the two major peaks correspond to the triggering of the financial crises and the European sovereign debt crisis of 2011.

Since correlation does not necessarily imply contagion, our purpose is to investigate cross-sector credit risk spillovers and the channels through which it propagates.

Few papers focus on systemic risk in the insurance sector: we contribute by specifically addressing contagion. The latter leads to two main empirical challenges: its definition and its measure.[1] We consider contagion as "correlation over and above what is explained by fundamental factors"[2] and adopt the excess correlation metric in order to investigate simultaneously the presence and magnitude of cross-sector risk spillovers.

Then, we assess the impact of business models on contagion. Several papers identify and explain their link to systemic risk without being explicit on this issue.[3] We add to this literature by providing evidence of the main determinants that intensify contagion.

Our research design allows us to identify and empirically investigate the channels through which contagion spreads. Our contribution here is the assessment of the asset-holding and guarantee channels for insurers and the additional collateral channel for banks. However, due to our focus on liquid CDS spreads limiting the size of our sample, we are unable to further segment the institutions we analyse, for instance, based on their size or regulatory license (f.i. reinsurers, non-life and life companies, composites).

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[1] For a survey of definitions and empirical methods see Forbes and Rigobon (2002), and Forbes (2012).

[2] Bakaert *et al*. (2005).

[3] In particular, the banking sector is investigated by Demirgüç-Kunt and Huizinga (2010), whereas insurers are analysed in Cummins and Weiss (2014).

Our findings underline the presence of cross-sector excess correlation. Firm-specific factors such as leverage and capital adequacy (for both sectors), size and investment income (for insurers), funding and income diversification (for banks), are relevant determinants. Instead, product-mix and specialisation (for insurers), the asset structure and the quality of loans (for banks) are not significant.

Finally, we provide empirical evidence of risk transmission channels and the increase in default risk and contagion driven by sovereign risk. For the insurance sector, the main transmission channel is the asset holding channel, which is exacerbated by the guarantee channel. For banks the collateral channel increases the asset-holding channel transmission mechanism, while the guarantee channel does not appear significant.

The remainder of this paper is organised as follows: "Literature review" section provides our literature review. "Data and methodology" section describes our data and methodological approach. "Results" section discusses our findings and, finally, "Robustness tests" section concludes our paper and identifies suggestions for further research and policy implications for both regulators and financial institutions.

Literature review

Our investigation of credit risk spillovers closely relates to three strands of literature, researching sovereign risk spillovers, cross-sector systemic risks and the impact of business models on risk profiles.

Sovereign risk spillovers between banks/insurers and countries

The European sovereign debt crisis stimulated several papers to investigate risk spillovers between countries and banks. Transmission channels are identified primarily in the asset-holding, collateral and guarantee channels.[4]

De Bruyckere *et al*.[5] and Acharya and Steffen[6] investigate the asset-holding and the collateral channels, finding that sovereign exposures of banks of most Eurozone countries react positively to increases in yields, especially in the so-called "periphery". Banks engaging in regulatory arbitrage purchasing sovereign bonds of peripheral countries show similarities: greater size, higher reliance on short-term funding, undercapitalisation and high risk-weighted assets. Similarly, Battistini *et al*.[7] investigate the relationship between the dynamics of sovereign yields and domestic banks' sovereign debt exposure in Eurozone countries, finding that most Eurozone banks responded to greater systemic risk by increasing the home bias of their sovereign portfolios.

Demirgüç-Kunt and Huizinga[8] focus on the guarantee channel and provide evidence that systemically large banks suffer a reduction in their market value in countries with large fiscal deficits, as these became too big to save. Furthermore, Acharya *et al*.[9] provide

[4] BIS (2011).
[5] De Bruyckere *et al*. (2013).
[6] Acharya and Steffen (2015).
[7] Battistini *et al*. (2014).
[8] Demirgüç-Kunt and Huizinga (2013).
[9] Acharya *et al*. (2014).

empirical evidence of a two-way feedback loop between financial and sovereign credit risk during the financial crisis driven by exposures in sovereign debt and the value of explicit government guarantees, which shrink in countries with large fiscal deficits.

The guarantee channel is also analysed through the investigation of the interdependences between sovereign and bank CDS spreads. Alter and Schüler[10] find that, for the period 2007–2010, contagion transferred from bank to sovereign CDS spreads before bank bailouts and took the opposite direction after them. Moreover, by expanding the sample period to 2004–2013, Avino and Cotter[11] evidence empirically that, in most countries with strained public budgets, sovereign CDS spreads have a leading role in explaining bank CDS spreads, while in developed countries the relationship seems to be inverted.

Regarding the insurance sector, only Dull *et al.*[12] investigate the specific sovereign risk transmission, finding that transmission is mainly driven by investments, with greater impact on systemically important insurers.

We contribute to the literature on risk transmission channels by investigating the effects of transmission channels on contagion from banks to insurers and vice versa. We hypothesise that the contagion across insurers and banks spreads through the asset-holding, guarantee and collateral channels of both sectors.

Systemic risk and contagion

The second relevant stream of literature refers to systemic risk and interconnectedness, with banks largely investigated.[13] Few studies focus on insurers and are relatively recent,[14] agreeing on systemic risk existing in the insurance sector and exhibiting an upward trend in both exposure and effects on financial instability, in particular due to the interconnectedness of large insurers. However, traditional insurance business models seem less prone to systemic issues when compared to the banking sector.[15]

The interconnectedness is analysed also by Billio *et al.*,[16] proposing several econometric measurers of systemic risk based on principal component analysis and the Granger causality test. Their empirical results indicate that illiquid assets of insurers could create systemic risk during crisis.

Chen *et al.*,[17] by using daily data on CDS spreads and intraday stock prices, measure systemic risk in the U.S. insurance sector, confirming that banks play a greater role on systemic risk than insurers. Despite similar in targeting systemic risk and the interconnectedness between banks and insurers, our paper differs from it by adopting a measure of contagion, instead of systemic risk, that does not require the identification of firms' default probabilities, intra-day stock prices and asset return correlations. Moreover, we examine

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[10] Alter and Schüler (2012).

[11] Avino and Cotter (2014).

[12] Düll *et al*. (2015).

[13] See, in particular, Allen *et al*. (2009, 2010) and Demirgüç-Kunt and Huizinga (2011).

[14] Under different methodologies, perspectives and conclusions, see Acharya *et al*. (2009), Harrington (2009), Baluch *et al*. (2011), Cummins and Weiss (2014), and Bierth *et al*. (2015). Moreover, Kessler (2013) argues that traditional insurance business models lead to insignificant systemic risks, unless deviations from them are present.

[15] Geneva Association (2010b).

[16] Billio *et al*. (2012).

[17] Chen *et al*. (2013).

the European market and a post-crisis dataset, and we distinguish the channels through which systemic risk propagates between banks and insurers instead of addressing empirically the issue of causality.

Weiß and Mühlnickel[18] take the analysis a step further by investigating the impact of the characteristics included in the IAIS methodology for global systemically important insurers.[19] They find that size has the greatest impact on systemic exposure of U.S. insurers during the financial crisis, with non-policyholder liabilities and higher ratios of investment income to net revenues being important drivers. More recently, the same authors[20] show that insurers' mergers tend to increase systemic risks. In addition, the involvement in non-traditional and non-insurance activities adds a destabilising effect, despite specific definitions vary.[21]

We contribute to this literature by documenting the evolution of cross-sector spillovers and their differences through firm-specific observable factors. Our hypothesis is that the characteristics of financial institutions influence systemic risk and contagion.

Insurance business models and risk profiles

This work relates also to studies on the impact of insurers' business models on risk profiles, where evidence is mixed and a unique definition and measure of systemic risk lacks.

After their extensive literature review, Eling and Pankoke[22] conclude that traditional insurance activities are less exposed than banking ones to systemic risks, with the exception of guaranteed and highly leveraged life insurance policies and annuities. At the same time, some non-traditional activities (short-term asset and liability management, issuance of credit derivatives and financial guarantees) put the two sectors in close contact but also offer diversification opportunities (insurance-linked securities and CAT bonds). Even a direct comparison of major insurers and banks underlines significant differences.[23]

Other authors highlight the role potentially played by non-traditional and quasi-banking operations in both life and non-life insurance,[24] especially involving credit-default swaps and securities' lending. Among them, Baluch *et al.*[25] stress the systemic implications of bancassurance linkages: resiliency is found in companies with less non-core capital sources and few links to credit-related instruments.

Schwarcz and Schwarcz,[26] by focusing on regulatory implications for the U.S. market, underline the need to cope with the evolving nature of systemic risk issues, after weaknesses of traditional supervisory approaches were exposed.

Cummins and Weiss[27] confirm the lower exposure to systemic issues of traditional insurance activities (yet, more relevant for life insurers), as well as the higher risk posed by quasi-banking operations and a generalised vulnerability to reinsurance spirals.

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18 Weiß and Mühlnickel (2014).
19 For an updated version, see IAIS (2015).
20 Weiß and Mühlnickel (2015).
21 Thimann (2015).
22 Eling and Pankoke (2012).
23 For a detailed analysis and a direct comparison, see Fitzpatrick (2013).
24 On this topic see, in particular, Jobst (2014) and Thimann (2015).
25 Baluch *et al*. (2011).
26 Schwarcz and Schwarcz (2014).
27 Cummins and Weiss (2014).

Reinsurance is investigated also by Chen *et al.*,[28] finding evidence of non-negligible effects in particular under extreme scenarios. However, these results are in contrast with Park and Xie[29] that exclude such exposures to produce significant market-wide consequences.

Instead, Bierth *et al.*[30] find that insurers contributed to financial instability during the financial crisis, through their interconnectedness, leverage, loss ratios and funding fragility. Moreover, by exploring the inner differences within and between business lines, no evidence is found on higher systemic threats posed by life insurers or by larger entities per se.

Trading activities, often called into explain exposure to contagion of insurers, have been investigated by Chiang and Niehaus,[31] finding that despite the presence of correlated trading across firms, these do not pose concerns about their contribution to systemic risks.

We contribute to this literature by analysing the impact of insurance business models on their vulnerability to contagion. Our hypothesis is that business models of banks and insurers influence cross-sector contagion. Finally, by focusing on Europe, we aim at extending the existing literature outside the U.S. and testing a different event triggering market turmoil.

Data and methodology

Since we are interested in capturing default risk, consistently with previous studies[32] we use CDS spreads on five-year senior debt contracts. We decided to use CDS spreads instead of bond spreads because they provide a direct and reliable measure of market's perception of credit risk in real time. The existing literature suggests that CDS are superior in capturing credit risk to bonds and stocks.[33]

We collect from Bloomberg Professional Service weekly CDS quotes for insurers and banks over the years 2006–2014. Table 1 lists the 9 insurance companies and the 21 banks included in our study. Due to the lack of liquidity of some contracts, we select only European CDS listed in the iTraxx financial index and obtain non-zero observations for at least 90 per cent of the sample period, adding reliability to our data.[34] The CDS spread series were transformed into arithmetic returns.

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28 Chen *et al.* (2014).

29 Park and Xie (2014).

30 Bierth *et al.* (2015).

31 Chiang and Niehaus (2016).

32 In particular, see Alter and Schüler (2012) and Avino and Cotter (2014).

33 Among others, see Hart and Zingales (2011), arguing that stocks are exposed to the upside of prices and that the bond alternative (yields on junior long-term debt) may be less liquid than CDS.

34 The potential concern that CDS do not express demand and supply curves as other listed securities is addressed by choosing liquid CDS, on one side, but also by referring to Bloomberg prices, that are gathered from credit market analysis that combines market quotes with active investors' quotations on over-the-counter markets. Hence, our sample combines both sources of information.

Table 1 List of banks and insurance companies

Insurers	*Countries*	*Banks*	*Countries*
Aegon NV	The Netherlands	Banco Bilbao Vizcaya Argentaria SA	Spain
Allianz SE	Germany	Banco Santander SA	Spain
Assicurazioni Generali SpA	Italy	Barclays Bank PLC	U.K.
Aviva PLC	U.K.	Bayerische Landesbank	Germany
AXA SA	France	BNP Paribas SA	France
Hannover Rueck SE	Germany	Commerzbank AG	Germany
Munich RE	Germany	Cooperatieve Centrale Raiffeisen	The Netherlands
Swiss Reinsurance Co. Ltd.	Switzerland	Credit Agricole SA	France
Zurich Insurance Co. Ltd.	Switzerland	Credit Suisse Group AG	Switzerland
		Danske Bank A/S	Denmark
		Deutsche Bank AG	Germany
		HSBC Bank PLC	U.K.
		ING Bank NV	The Netherlands
		Intesa Sanpaolo SpA	Italy
		Lloyds Bank PLC	U.K.
		Mediobanca SpA	Italy
		Societe Generale SA	France
		Standard Chartered Bank	U.K.
		Royal Bank of Scotland PLC/The UBS AG	U.K. Switzerland
		UniCredit SpA	Italy

This table shows the list of 21 banks and 9 insurance companies included in our analysis. For each insurer and bank, we also report their home country. These financial institutions are the members of the EU iTraxx financial index.

Despite the sample size is small, especially for insurers, this outcome is due to our preference for liquid CDS in order to better reflect their price changes into our analysis. The sample, therefore, represents the whole population of entities with highly liquid CDS and is consistent with previous research.[35] Moreover, the limited number of entities does not allow us to further investigate segments of companies (f.i. by size or licensed activities) and forces us to consider these elements indirectly, as explained below.

Measuring contagion

Definitions and measures of contagion diverge significantly within the literature.[36] In this paper, we rely on the widely used definition of Bakaert *et al.*[2], where contagion is "excess correlation, that is correlation over and above what one would expect from economic fundamentals".

To address the issue of cross-industry contagion in the financial sector, we adopt the model proposed by Anderson[37] and De Bruyckere *et al.*[5] Assuming that CDS spread changes follow a linear factor structure, we can decompose correlations into fundamental and excess correlations with the following model:

$$E\left(\Delta \mathrm{CDS}_{b,t} \Delta \mathrm{CDS}_{c,t}\right) = E[(\beta F' + \in)(\beta F' + \in)'] = \beta E[F'F]\beta' + E[\in\in'], \qquad (1)$$

[35] For instance, in the U.S. market, Chen *et al.* (2013) investigate CDS of 11 insurers and 22 banks.

[36] For an overview of methodological approaches, see Thimann (2015) and Jobst (2014). In terms of systemic risk indicators, a detailed analysis is provided by Liedtke (2011) and the Geneva Association (2011a, b).

[37] Anderson (2011).

where $\Delta CDS_{b,t}$ and $\Delta CDS_{c,t}$ are, respectively, vectors of insurers' and banks' CDS spread changes; β is a matrix of factors exposures; F is a vector of market-wide factors explaining the economic fundamentals of correlation (detailed below); ε is a vector of model errors.

Excess correlation between an insurer b and a bank c is then defined as

$$\text{Excess correlation}_{i,j,t} = E\left[\in_{b,t};\ \in_{c,t}\right]. \qquad (2)$$

We identify four fundamental risk factors, collected from Bloomberg Professional Service.

The first variable is the iTraxx Europe index, composed by the 125 most liquid CDS of European listed companies, to control for market-wide credit risk: higher iTraxx valuations indicate its increase and we expect a positive relationship with CDS spread changes.

To control for market-wide volatility expectations and risk aversion, we include the CBOE volatility index (VIX): the higher the volatility, the higher the economic uncertainty and hence the response of credit spreads.

European market-wide business expectations are considered through the inclusion of the Eurostoxx 600 index, which comprises large, mid and small capitalisation companies across 18 European countries. We expect a negative relation with CDS spread changes, since improvements on business expectations reduce credit risk.

Finally, we include the country-specific term spread, as the difference between 10-year government bond yields of each firm's home country and the 1-year Euribor/Libor rate. The prediction for this variable is uncertain, since it could be linked to expectations about future economic conditions (negative relation) and to perceptions of sovereign risk (positive relation).

Therefore, the factor model results as follows:

$$\text{Ln}\left(\Delta \text{CDS}_{i,t}\right) = \alpha + \beta_1 \text{Itraxx}_t + \beta_2 \ln(\text{Vix}_t) + \beta_3 \ln(\text{Sxxp}_t) + \beta_4 \text{Term}_t + \varepsilon_{i,t}, \qquad (3)$$

where $\text{Ln}(\Delta\text{CDS}_{i,t})$ is the logarithm of the arithmetic change in CDS spreads for bank/insurer or country i; Itraxx_t is the time series of European iTraxx index arithmetic change; $\ln(\text{Vix}_t)$ is the logarithm of the VIX index; $\ln(\text{Sxxp}_t)$ is the log of arithmetic changes in the EU stock index; Term_t is the term spread.

To control for time variation, as in De Bruyckere *et al.*,[5] we split the time sample and run the factor model separately for each year.

Insurer/bank characteristics and excess correlation

After measuring cross-sector contagion, we continue by investigating the impact of banks' or insurers' business models on excess correlation. For each insurer–bank combination, excess correlation is measured weekly: it is transformed to a quarterly basis consistently with the availability of accounting data.

Cross-sectional differences in excess correlation are analysed by regressing this variable on a set of firm-specific characteristics, resulting in the following model:

$$\text{Excess correlation}_{i,j,t} = \alpha + \beta_1 X_{i,t} + \eta_{i,j,t} + \varepsilon_{i,j,t}, \qquad (4)$$

where $\text{Excess correlation}_{i,j,t}$ is the excess correlation between insurer i and bank j at time t; $X_{i,t}$ is a vector of insurer or bank firm-specific ratios; $\eta_{i,j,t}$ is the two-way fixed effect.

For insurance companies, we focus on the following factors that summarise their business models accordingly with the literature: level of capitalisation, income structure, specialisation in life insurance and product-mix within policyholder liabilities.

The level of capital is crucial for prudential regulation in the whole financial sector, since it acts as a buffer for unexpected losses: we expect lower credit risk and excess correlation for well-capitalised insurers. As a proxy, in the lack of consistent cross-country firm-specific data on regulatory capital in the path to Solvency 2, we use the ratio of tangible equity capital to total assets, a variable in line with investors' and financial markets' perspectives firms' capitalisation.

The second variable is the proportion of investment income to total income, measuring the dependency of profitability from financial markets. We hypothesise that the higher this ratio, the higher the volatility of returns and hence the credit risk.

Within life insurers, product-mix affects the exposure to financial risks. Hybrid products, like unit-linked business, are similar to structured investment products where the investment risk is borne by clients. Hence, the liability structure is influenced by credit risk. We take this into account by using two ratios: life policy provisions to total provisions (as an indicator of specialisation) and the ratio of other provisions to total provisions (as a proxy for such hybrid products). For the first ratio, we expect life insurers to be more exposed to systemic risks due to the nature of their investment portfolio and benefits' outflows more closely related to economic cycles. For the latter, a greater share of financial risk embedded in contracts could render the liability side prone to systemic issues.

Finally, as a control variable, we add the logarithm of total assets of insurance companies. Several contributions[38] claim that larger insurance companies could become systemically relevant as they became too-interconnected-to-fail.

For banks, the impact of business models on excess correlation is measured through capitalisation, asset structure, income structure and funding risk.

Capitalisation is based on two different ratios: the regulatory Tier 1 ratio and the tangible equity capital as defined for insurers. We expect a lower excess correlation for banks that are more capitalised, as in previous studies.[39]

Different compositions of assets are investigated through the ratio of loans to total assets. Banks with bigger banking portfolios trade less in securities and are perceived by capital markets as less risky.[39] We expect less excess correlation for entities with higher values of this ratio (i.e., commercial banks).

On the liability side, the funding structure is an important determinant of the risk profile of a bank. Several papers[40] claim that non-deposit funding increases risk by being unstable. In addition, banks with potentially volatile funding are more exposed to sovereign risk in the perspective of both supervisors[4] and academic research.[5] We measure the impact of a bank's funding structure with the ratio of deposit to total funding, expecting that higher values are associated with less contagion.

Finally, the income structure, in terms of diversification from traditional business, is measured by the ratio of non-interest income to total income. Non-interest activities are

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[38] Among others, see IAIS (2015) and Acharya *et al*. (2009).

[39] Altunbas *et al*. (2011).

[40] Among others, we refer to Demirgüç-Kunt and Huizinga (2010) and Huang and Ratnovski (2011).

more volatile, especially during periods of financial stress. Beltratti and Stulz[41] show that the worst performing banks are those with more diversified activities, whereas non-traditional activities are found to have a higher contribution to systemic risk.[42] Therefore, we hypothesise that diversified banks exacerbate the contagion channel to the insurance industry.

The summary statistics of the sectoral firm-specific variables are presented in Table 2.

We stress the fact that our choice of variables linked to business models allows us to obtain, despite in an indirect way, insight on differences arising not only from a different license of entities (f.i. life and non-life insurers or composites), but provides more reliable results in capturing implicit differences in their business models (f.i. the weight of quasi-banking products for insurers, the role played by results on investments, etc.).

Contagion channels

To investigate contagion channels, we adopt a two-way fixed-effects estimation, which considers both unobserved heterogeneity and instrumental variables. We focus altogether on three channels of contagion that can affect co-movements of CDS spreads.

In the case of insurers, we focus on the asset-holding and the guarantee channels. Since insurers hold a larger proportion of their assets in marketable securities, we expect that the asset-holding channel is pivotal in transmitting contagion to banks. Within this channel, the sovereign exposure and the involvement in non-traditional financial activities are the primary drivers: we expect that contagion is higher with more sovereign exposures and if the home country becomes riskier. Insurers, like banks, exhibit a significant level of home bias through their bond portfolio.[7]

Unfortunately, micro-level data are unavailable and exposures are altered by hedging or trading derivatives. Given this limitation, we use the balance sheet ratio of sovereign investments over total assets to proxy the overall sovereign risk exposure. The hypothesis is that insurers' default risk increases with a higher default risk of sovereign bonds.

However, insurers may also benefit from higher yields and larger portfolios could improve diversification, reducing systemic risk.[43] The increasing effect of the asset-holding channel is therefore measured by interacting the sovereign exposure to the 10-year yield of the home-country bond.

The Geneva Association[44] and the IAIS[19] claim that non-traditional non-insurance activities, under some circumstances, are drivers of systemic risk[45]: therefore, as a proxy, we include the ratio of loans and mortgages over total assets and we control for the increasing risk by interacting it with the average banking CDS spread.

Finally, as a control variable, we add the investment yield ratio, which considers the risk and return characteristics of the overall investment portfolio.

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41 Beltratti and Stulz (2012).

42 Brunnermeier *et al.* (2012).

43 Slijkerman *et al*. (2013).

44 The Geneva Association (2010a).

45 Being based on a description of products' features, definitions and contents of non-insurance and (or) non-traditional activities vary widely. However, the common issue of such activities is an exposure to market and liquidity risks that is not typical of the insurance business. These vulnerabilities have systemic implications by allowing shocks to spread across markets, or by requiring fire sales of assets contributing to market volatility.

Table 2 Summary statistics of insurers' and banks' specific variables

Variables	*Mean*	*Std. deviation*	*Obs.*
Insurance-specific variables			
Equity/total assets	0.078	0.028	288
Investment income/total operating income	0.712	0.424	288
Life policy benefits/total insurance reserve	0.468	0.172	288
Other insurance reserves/total insurance reserves	0.293	0.229	288
Total assets	12.63	0.790	288
Insurers CDS spread	89.83	60.44	288
Bank-specific variables			
Tier 1 capital ratio	11.337	2.937	672
Loan/total assets	0.435	0.161	672
Loan/total assets * non-performing loans/total assets	0.011	0.012	672
Income diversification	0.571	0.234	672
Funding risk	0.159	0.110	672
Banks CDS spreads	102.78	75.16	672
Excess correlations	0.470	0.594	672

This table shows the summary statistics for the bank- and insurance-specific variables used in Equation 2. Statistics for the variables are calculated at the insurance-time and bank-time level.

The guarantee channel, which is related to the too-big-to-fail status, is present also for insurers. When the fiscal position of sovereign countries deteriorates, the government guarantee is weakened especially for systemically important insurers. To control for this, we add the natural logarithm of total assets as a proxy of the too-big-to-fail status.

We believe that the collateral channel is not relevant for insurers, due to the inversion of the operating cycle: therefore, we do not investigate it further. The collateral channel is instead relevant for banks, due to the central role of their funding structure. We lack micro-level data also in this case and adopt the ratio of the total exposure in securities over total assets as a proxy.

The increasing effect of the portfolio channel mechanism is measured also for banks by interacting the portfolio size variable with the 10-year yield of home-country bonds.

Moreover, to control the overall level of risk, we consider the amount of available cash: the more cash banks hold, the less they are perceived risky and exposed to liquidity risk.

The asset-holding channel could be exacerbated if banks require collateral in short-term funding from central banks. In addition, market risk could increase if banks use extensively short-term funding. We investigate this channel by adding the interaction term between the ratio of portfolio of securities to total assets and the short-term funding ratio.

Finally, the guarantee channel is considered by adding the logarithm of total assets.

Table 3 presents the summary statistics for the analysis of contagion channels.

Results

Excess correlation

According to our model, if we obtain an increase in the correlation due to changes in fundamental factors, the error component would be zero and thus contagion is not present.

Table 3 Summary statistics for the contagion channels analysis

Variables	*Mean*	*Std. deviation*	*Obs.*
Insurance companies			
Asset holding channel			
Yield investments	0.078	0.011	288
Sovereign invest/total assets	0.291	0.115	288
Sovereign invest/total assets * 10-year yield home country bond	0.822	0.703	288
Insurers loans and mortgages/total assets	0.103	0.077	288
Insurers loans and mortgages/total assets * mean banks	0.183	0.138	288
Guarantee channel			
Size	12.63	0.790	288
Banks			
Asset holding channel			
Cash/total assets	0.028	0.025	672
Portfolio/total assets	0.243	0.137	672
Portfolio/total assets * 10-year yield home country bond	0.965	0.703	672
Tier 1 * portfolio/total assets	3.068	1.625	672
Collateral channel			
Short-term funding/total assets * portfolio/total assets	0.049	0.057	672
Guarantee channel			
Size	13.79	0.823	672

This table shows the summary statistics for the bank- and insurance-specific variables used for investigating the contagion channels. Statistics for the variables are calculated at the insurance-time and bank-time level.

Table 4 CDS factor model

Years	*Itraxx*	*Vix*	*Sxxp*	*Terms*	*Adj.* R^2
2006	0.215 (5.931)***	0.152 (4.105)***	0.272 (4.028)***	0.447 (3.631)***	0.54
2007	0.065 (3.483)***	0.362 (16.354)***	0.0049 (0.284)	−1.784 (−15.554)***	0.77
2008	0.546 (17.087)***	−0.104 (−1.791)	−0.102 (−1.464)	−0.427 (−5.976)***	0.35
2009	−0.047 (−0.903)	0.016 (0.177)	−0.525 (−6.494)***	−0.045 (−0.598)	0.45
2010	0.041 (0.566)	0.559 (10.070)***	0.376 (11.675)***	0.050 (0.326)	0.33
2011	0.402 (5.099)***	−0.347 (−6.328)***	−0.587 (−9.499)***	0.702 (5.277)***	0.70
2012	0.08 (2.780)**	0.048 (5.705)***	−0.213 (−6.041)***	0.207 (1.368)	0.52
2013	0.345 (7.417)***	0.154 (12.658)***	0.072 (3.390)***	0.592 (3.516)***	0.58
2014	0.40 (8.089)***	0.122 (2.911)**	0.068 (2.616)**	0.527 (3.345)***	0.72

This table reports yearly coefficients between 2006 and 2012 for the four factor variables used in our factor models for banks and insurers CDS spreads. The variables included are the European iTraxx index, the VIX volatility index, the Eurostoxx 600 (Sxxp) and the term spread between 10-year government bond for each country and the 1-year Euribor/Libor rate. For each of these variables, we report the average yearly coefficient, the White robust t-values (in brackets) and p-values. We also report the yearly adjusted R^2. t-values in brackets.

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

Table 4 shows average coefficients and their significance in the bank–insurer factor model of Equation 3.

Consistently with previous studies,[5] we run our model yearly in order to consider both the time variation of coefficients and the effect of major market events. We expect all fundamental factors to be less significant during crisis periods, giving evidence of contagion.

In analogy with empirical findings of Collin-Dufresne *et al.*,[46] we observe that most variables are significant, confirming their ability to explain movements in credit spreads. In particular, we notice the importance of the iTraxx Europe index in explaining CDS spread changes, in line with Ejsing and Lemke.[47] We also show a spike in iTraxx coefficients during the crisis years 2008 (0.546) and 2011 (0.402), arguing that in those periods most of movements of bank and insurer CDS spreads are affected by the overall index.

In line with our expectation, we obtain an overall positive and statistically significant relationship between VIX and credit spread. Increased volatility results in economic uncertainty and in more probability of default.[46]

The return of Eurostoxx 600 shows mixed outcomes, generally negative and statistically significant during crisis years: positive changes in the business climate reduce credit risk perception.

As expected, we obtain mixed results investigating the term spread. It is generally positive and statistically significant, especially at the end of the sample period. This is likely related to the fact that an increase in peripheral European government 10-year yields could have had a positive effect on CDS spreads. We therefore confirm the previous finding that the slope of the term structure is not significant.[46]

If we focus on the crisis period, we notice that the adjusted R^2 halves from 0.77 in 2007 to 0.35 in 2008 and falls from 0.70 in 2011 to 0.52 in 2012. At the same time, coefficients of other variables are also lower than in pre-crisis period, or not statistically significant. Overall we have much lower significance of other variables than the iTraxx index during the crisis periods and the fundamental factors are less able to explain bank–insurer correlations. This makes crucial to analyse the excess correlation, represented by the error factor.

Banks and insurance business models and contagion

In this section, we examine the firm-specific determinants of banking–insurance contagion, measured by excess correlation. To compare the relationship between one insurance and different banks or one bank and different insurance companies, we opt for a two-way fixed effect model, where the error term is the sum of an unobserved effect and an idiosyncratic error. This allows to distinguish the impact of sector-specific variables through insurer- and bank-time fixed effects. All independent variables are standardised in order to show the impact on excess correlation of a one standard deviation change of each dependent variable. To control for the overall impact of default risk in the banking sector, we decided to incorporate the logarithm of weighted average CDS spreads. Results are presented in Table 5.

Columns 1 and 2 show the effect of insurance characteristics on contagion. We analyse the effect of four characteristics: capitalisation (the ratio of total shareholders' equity–capital, reserves and retained earnings–over total assets), investment income (investment income to total operating income), the composition of policyholder provisions (life

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[46] Collin-Dufresne *et al*. (2001).
[47] Ejsing and Lemke (2011).

Table 5 Excess correlation and firm-specific characteristics

	Excess correlation			
	(1)	*(2)*	*(3)*	*(4)*
Ln (banks CDS spread)	0.896*** (18.185)	0.896*** (18.284)	0.975*** (14.697)	0.942*** (13.241)
Insurers variables				
Size		0.09* (1.950)		
Equity/total assets	−0.396*** (−12.738)	−0.393*** (−11.273)		
Investment income	0.027*** (4.461)	0.028*** (4.728)		
Life policy benefits/total assets	0.042 (0.753)	0.038 (0.658)		
Other policy benefits/total assets	0.038 (0.656)	0.032 (0.529)		
Banks variables				
Equity/total assets			−0.056* (−2.391)	
Tier 1 ratio				−0.058** (−2.825)
Income diversification			0.015* (1.786)	0.022* (2.289)
Short-term funding/total funding			0.063*** (4.462)	0.065*** (4.833)
Loans/total assets			−0.042 (−0.981)	−0.014 (−0.326)
Loans/total assets * NPL/total assets				0.037 (1.342)
Observations	6,362	6,362	5,229	4,986
Adjusted R^2	0.349	0.353	0.299	0.310
Insurer-time FE	Yes	Yes	Yes	Yes
Cluster	Insurer-time	Insurer-time	Insurer-time	Insurer-time
Number of insurers	9	9	9	9
Number of banks	21	21	21	21

This table shows the relationship between insurance- and bank-specific variables and the excess correlation coefficient. In Columns 1 and 2, we regress the excess correlation coefficient on a set of insurance-specific variables, while controlling for insurer-time fixed effects. In Columns 3 and 4, we regress the excess correlation coefficient on a set of bank-specific variables, while controlling for bank-time fixed effects. Robust t-statistics are reported in parenthesis.

t-values in brackets.

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

provisions over total liabilities and other provisions to total liabilities) and size (natural logarithm of total assets).

We find that capitalisation has a significant and high impact on excess correlation: insurers with less own funds are more vulnerable to contagion. The coefficient is higher in magnitude than the similar ratio in banks, suggesting that it is a relevant driver of contagion from banks to the insurance sector. This finding confirms results of Bierth *et al.*[30] and Thimann,[21] which claim that leverage is a predominant driver of systemic risk and contagion in the insurance sector. The impact is significant: a one standard deviation increase in capitalisation leads to a decrease in cross-industry contagion of roughly 39 per cent.

As expected, the investment income ratio has a positive and significant coefficient, confirming our hypothesis that the higher the dependence of performance on financial markets, the higher the cross-industry contagion. This result stresses systemic implications of market risks for insurers,[18] included explicitly within supervisory scrutiny only with Solvency 2.

The composition of policy liabilities is insignificant under both specifications, claiming that insurance activities, independently from the product mix, are not considered as exposed to systemic issues as banking activities, probably due to the differences in timing and liquidity of provisions.[48]

Finally, size is significant and relevant, providing the first evidence of the role of the guarantee channel for insurers within a contagion framework. In addition, it adds evidence on the relevance of this metric in assessing systemic risk.[19]

In Columns 3 and 4, we focus on banks through four determinants: capitalisation (measured by the ratio of total shareholders' equity–capital, reserves and retained earnings–over total assets equity, or the Tier 1 ratio), income diversification (the ratio of non-interest income over total income), funding risk (short-term funding to total funding), asset structure (loans to total assets) and loans quality (loans over total assets, times non-performing loans to total assets). In this case, we do not control for size, because banks considered in our sample were all defined systemically important by the ECB.

The level capitalisation, in both specifications, has the highest and negative impact. This result confirms the central role of capital as a driver of credit risk contagion in banks.

We also find a positive and significant impact of income diversification, confirming the hypothesis that non-interest activities have a positive impact on systemic risk and contagion.

We find again a positive and significant coefficient for the funding structure. This result supports our hypothesis that banks' funding models impact cross-industry contagion and it indicates that the collateral channel also spreads to the insurance sector.

The asset structure is not significant: this result contrasts our hypothesis, as we expected that retail-oriented banks could diminish cross-sector contagion.

Finally, we also interact the loan to asset ratio with the level of non-performing loans to total assets. If the quality of loans over the total portfolio is relevant in explaining excess correlations, the sign would be positive. However, despite the sign is confirmed, it is not significant: therefore, the quality of the loan portfolio is not a determinant of excess correlation between banks and insurers. In economic terms, this result indicates that traditional banking activities do not have an impact in terms of credit risk contagion to the insurance sector.

Contagion channels

Since firm-specific characteristics are closely linked to excess correlation, in this section we investigate further the channels of insurers-to-banks and banks-to-insurers contagion.

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[48] Paulson *et al.* (2012).

We start by analysing the paths of risk transmission for insurers, namely the asset-holding and the guarantee channels. Then, a similar approach is applied to banks extending also on the collateral channel.[4]

To test the asset-holding channel, we regress the excess correlation on a set of insurers' investment portfolio characteristics and a control variable expressive of investments' yield. The insurer-time fixed effects model allows us to investigate the impact of firm-specific factors on the excess correlation. As our previous results indicate, we also control for the role of the banking credit risk by adding the natural logarithm of banks CDS spreads. Results are shown in Table 6.

Results in Column 1 validate our hypothesis regarding the impact of the sovereign portfolio of insurers on cross-sector contagion. The coefficient of the sovereign exposure over total assets is negative and significant. This result indicates that sovereign risk transmission is mainly explained by the home bias rather than the overall sovereign exposure. Furthermore, large and better-diversified insurers are less vulnerable to market risks. The interaction coefficient of sovereign exposure and the home country 10-year yield is positive, consistently with our hypothesis regarding the asset-holding channel. In terms

Table 6 Contagion channels: insurers to banks

	Excess correlation		
	Asset holding		*Guarantee channel*
	(1)	*(2)*	
Ln (banks CDS spread)	0.989*** (15.983)	0.989*** (16.511)	0.989*** (17.005)
Yield investments	0.021** (3.173)	0.022** (3.290)	0.021** (3.278)
Sovereign investments/total assets	−0.024* (−1.710)	−0.027 (−1.111)	−0.025 (1.028)
Sovereign investment/total assets * 10-year yield home country bond	0.206*** (13.155)	0.208*** (12.571)	0.216*** (13.287)
Insurers loans and mortgages/total assets		0.024 (0.654)	−0.023 (−0.302)
Insurers loans and mortgages/total assets * mean banks CDS		0.097 (1.261)	0.101* (2.337)
Size			0.307*** (8.064)
Observations	5,577	5,577	5,577
Adjusted R^2	0.346	0.357	0.364
Insurer-time FE	Yes	Yes	Yes
Cluster	Insurer-time	Insurer-time	Insurer-time
Number of insurers	9	9	9
Number of banks	21	21	21

In this table, we show the results of our investigation of the two insurers-to-banks contagion channels. In Columns 1 and 2, we test the existence of the asset holding channel by regressing the excess correlation coefficient on a set of portfolio characteristics of insurance companies, while controlling for the overall level of risk in the banking sector and insurer-time fixed effects. In Column 3, we investigate the presence of the guarantee channel, while also controlling for the overall level of risk in the banking sector and insurer-time fixed effects. Robust t-values are shown in brackets. t-values in brackets.

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

Table 7 Contagion channels: banks to insurers

	Excess correlation			
	Asset holding channel		*Collateral channel*	*Guarantee channel*
	(1)	*(2)*		
Ln (banks CDS spread)	0.779*** (13.474)	0.779*** (13.476)	0.789*** (13.577)	0.784*** (13.142)
Cash/total assets	−0.038* (−2.179)	−0.035* (−2.032)	−0.038* (−2.191)	−0.039* (−2.242)
Portfolio/total assets	−0.135*** (−5.493)	−0.142*** (−4.058)	−0.142*** (−5.511)	−0.144*** (−5.474)
Portfolio/total assets * 10-year yield home country bond	0.170*** (5.917)	0.179*** (5.718)	0.167*** (5.872)	0.168*** (5.874)
Tier 1 * portfolio/total assets		0.038 (1.243)		
Short-term funding/total assets * portfolio/total assets			0.021* (2.140)	0.020* (2.152)
Assets				0.024 (1.201)
Observations	6,120	6,120	6,120	6,120
Adjusted R^2	0.311	0.312	0.312	0.313
Bank-time FE	Yes	Yes	Yes	Yes
Cluster	Banks-time	Banks-time	Banks-time	Banks-time
Number of insurers	9	9	9	9
Number of banks	21	21	21	21

This table illustrates three channels of banks-to-insurers contagion. In Columns 1 and 2, we regress the excess correlation coefficient on a set of banks' characteristics of their portfolio of securities. We control for the average credit risk in the banking sector and the banks-time fixed effects. In Columns 3 and 4, we test respectively the presence of a collateral and a guarantee channel. Robust *t*-values are shown in brackets. *t*-values in brackets.

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

of impact, the coefficient states that a standard deviation increase in the interaction term raises the excess correlation coefficient by 20 per cent.

In Column 2, we analyse if non-traditional activities of European insurers are a potential driver of systemic risk and could increase contagion.[19] If there is a contagion channel, the interaction term of the ratio of loans and mortgages to total assets and the mean banks' CDS should be positive: despite this is the case, the coefficient is not significant.

In Column 3, we test the guarantee channel. If implicit guarantees exist for insurers, the asset-holding channel should have a greater impact on risk transmission. Therefore, we control for size and find that the coefficient is positive and highly significant.

We also find an increase in both interaction coefficients. The coefficient of sovereign exposure and the home-country 10-year yield increases in magnitude from 0.208 to 0.216 and remains significant. The interaction term of the ratio of loans and mortgages to total assets and the mean banks' CDS increases in size from 0.09 to 0.101 and becomes significant. This is consistent with the claim that involvement in non-insurance activities for systemically important insurers has an impact on financial stability.

Table 8 Robustness test alternative factor model for the insurers-to-banks channels

	Excess correlation		
	Asset holding		*Guarantee channel*
	(1)	*(2)*	
Ln (banks CDS spread)	1.665*** (15.983)	1.665*** (16.510)	1.665*** (16.958)
Yield investments	0.035** (3.173)	0.036** (3.290)	0.036** (3.279)
Sovereign investments/total assets	−0.042 (−0.985)	0.004 (0.114)	0.043 (1.027)
Sovereign investment/total assets * 10-year yield home country bond	0.347*** (13.155)	0.351*** (12.573)	0.364*** (13.307)
Insurers loans and mortgages/total assets		0.040 (0.315)	−0.039 (−0.315)
Insurers loans and mortgages/total assets * mean banks CDS		0.163 (1.278)	0.117* (2.457)
Size			0.517*** (4.689)
Observations	5,577	5,577	5,577
Adjusted R^2	0.347	0.367	0.379
Insurer-time FE	Yes	Yes	Yes
Cluster	Insurer-time	Insurer-time	Insurer-time
Number of insurers	9	9	9
Number of banks	21	21	21

This table shows a robustness test for different contagion channels. The setup is similar to Table 6. The excess correlation coefficient is now calculated based on a factor model with only one common variable: the European iTraxx index. *t*-values in brackets

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

Results for the banking sector are presented in Table 7, with the addition of the collateral channel and controlling for fixed effects and the overall sectoral credit risk.

Columns 1 and 2 confirm our hypothesis for the asset-holding channel.

We find that the cash retained by banks reduces contagion, due to the importance of liquidity buffers in reducing the overall riskiness and, specifically, not spreading contagion.

The coefficient of the portfolio of securities over total asset is significant and negative, indicating that banks with higher portfolios of securities are better diversified.

Regarding sovereign risk, we again find a positive coefficient for the interaction variable, indicating that there could be contagion issues involving the asset-holding channel. In economic terms, the coefficient is high in significance and magnitude, indicating that a one standard deviation change increases cross-sector contagion by 0.17. Also, when we add a control for the potential interaction between size over total assets of the portfolio of securities and the regulatory capital, the coefficient remains positive and significant.

The results in Column 3 corroborate the collateral channel hypothesis in enhancing the asset-holding channel. Results show that banks with a higher ratio of short-term funding increase the asset-holding channel mechanism from 0.167 by 0.021 (roughly, a 12 per cent increase).

Column 4 presents the analysis of the guarantee channel. We find that the size coefficient is not significant, suggesting that the guarantee channel is not relevant for banks. We believe that this result is related to the fact that banks in our sample are all significant in terms of dimensions and interconnectedness. Other coefficients related to the asset-holding and the collateral channels remain significant and relatively stable.

Robustness tests

In this section, we perform two robustness checks. The first uses alternative factor models for the excess correlation coefficient, while the second adopts a different clustering of standard errors: both confirm our findings.

To make sure that our main findings are not biased by the choice of the factor model, we calculate the excess correlation coefficient including only the iTraxx European CDS index on a yearly basis. Then, we reinvestigate the impact of the different contagion channels. Results, presented in Tables 8 and 9, confirm our main findings. We again find evidence in favour of an asset-holding channel and a guarantee channel for insurance companies. For banks, we confirm the presence of an asset-holding channel enhanced by the collateral channel. Again we do not find evidence of a guarantee channel for bank companies.

Table 9 Robustness test: alternative factor model for the banks-to-insurers channels

	Excess correlation			
	Asset holding channel		*Collateral channel*	*Guarantee channel*
	(1)	*(2)*		
Ln (banks CDS spread)	1.311*** (13.475)	1.312*** (13.476)	1.329*** (13.557)	1.321*** (13.144)
Cash/total assets	−0.065* (−2.181)	−0.059* (−2.132)	−0.064* (−2.198)	−0.066* (−2.344)
Portfolio/total assets	−0.228*** (−5.531)	−0.290*** (−4.518)	−0.238*** (−5.501)	−0.242*** (−5.544)
Portfolio/total assets * 0-year yield home country bond	0.287*** (5.928)	0.301*** (5.781)	0.282*** (5.892)	0.283*** (5.898)
Tier 1 * portfolio/total assets		0.065 (1.267)		
Short-term funding/total assets * portfolio/total assets			0.033* (2.145)	0.034* (2.153)
Assets				0.041 (0.531)
Observations	6,120	6,120	6,120	6,120
Adjusted R^2	0.322	0.323	0.324	0.324
Bank-time FE	Yes	Yes	Yes	Yes
Cluster	Banks-time	Banks-time	Banks-time	Banks-time
Number of insurers	9	9	9	9
Number of banks	21	21	21	21

This table shows a robustness test for different contagion channels. The setup is similar to Table 7. The excess correlation coefficient is now calculated based on a factor model with only one common variable: the European iTraxx index. *t*-values in brackets

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

Table 10 Robustness: cluster robust standard errors for the insurers-to-banks channels

	Excess correlation		
	Asset holding		*Guarantee channel*
	(1)	*(2)*	
Ln (banks CDS spread)	0.989*** (15.983)	0.989*** (16.511)	0.989*** (17.005)
Yield investments	0.021** (3.173)	0.022** (3.290)	0.024** (3.278)
Sovereign investments/total assets	−0.024 (−0.985)	0.003 (0.114)	0.025 (1.028)
Sovereign investment/total assets * 10-year yield home country bond	0.206*** (13.155)	0.208*** (12.571)	0.217*** (13.287)
Insurers loans and mortgages/total assets		0.024 (0.315)	−0.024 (−0.301)
Insurers loans and mortgages/total assets * mean banks CDS		0.097 (1.261)	0.102* (2.347)
Size			0.307*** (4.689)
Observations	5,577	5,577	5,577
Adjusted R^2	0.346	0.357	0.364
Insurer-time FE	Yes	Yes	Yes
Cluster	Insurer	Insurer	Insurer
Number of insurers	9	9	9
Number of banks	21	21	21

This table shows a robustness test for the different contagion channels. The setup is similar to Table 6. Standard errors are clustered on an insurer level instead on insurer-time level. *t*-values in brackets.

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

As a second robustness check, we look at the impact of an alternative clustering of standard errors. More precisely, we cluster the robust standard errors at the insurer or bank level instead of insurer-time or bank-time level. Clustering standard errors at the insurer-time/bank-time level allowed standard errors to be correlated within the same insurer/bank at any point in time. With the different setting, we allow error terms to be correlated over time within the same bank/insurer. The results of this alternative clustering setting are presented in Tables 10 and 11 and confirm our main findings.

Conclusions

This paper provides an empirical assessment on risk spillovers between European banks and insurers during both the global financial crisis and the sovereign debt crisis. Despite several papers exist on systemic risk and the determinants of banks' or sovereign credit risk, to the best of our knowledge, no one has empirically investigated cross-sector contagion channels.

We add new evidence to this literature by investigating market-wide and firm-specific determinants that drive contagion in each risk transmission channel. Our methodology derives from contagion defined as excess correlation. Our controls on market-wide factors

Table 11 Robustness: cluster robust standard errors for the banks-to-insurers channels

	Excess correlation			
	Asset-holding channel		*Collateral channel*	*Guarantee channel*
	(1)	*(2)*		
Ln (banks CDS spread)	0.779*** (13.474)	0.780*** (13.459)	0.789*** (13.576)	0.784*** (13.142)
Cash/total assets	−0.038* (−2.179)	−0.035* (−2.032)	−0.038* (−2.192)	−0.039* (−2.242)
Portfolio/total assets	−0.135*** (−5.493)	−0.172*** (−4.059)	−0.142*** (−5.510)	−0.144*** (−5.475)
Portfolio/total assets * 10-year yield home country bond	0.171*** (5.918)	0.178*** (5.719)	0.167*** (5.871)	0.168*** (5.875)
Tier 1 * portfolio/total assets		0.038 (1.244)		
Short-term funding/total assets * portfolio/total assets			0.020* (2.141)	0.021* (2.153)
Assets				0.024 (0.531)
Observations	6,120	6,120	6,120	6,120
Adjusted R^2	0.311	0.312	0.312	0.313
Bank-time FE	Yes	Yes	Yes	Yes
Cluster	Banks	Banks	Banks	Banks
Number of insurers	9	9	9	9
Number of banks	21	21	21	21

This table shows a robustness test for different contagion channels. The setup is similar to Table 7. Standard errors are clustered on a bank level instead of bank-time level. *t*-values in brackets.

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

(credit risk, market risk, volatility and term spread) confirm previous evidence of cross-sector excess correlation, during crisis years, in terms of both significance and volatility.

Subsequently, we investigate firm-specific determinants of contagion declined for the two sectors. We find that leverage, size and investment income are important determinants of contagion for insurers, while product-mix and specialisation in the life business are not. In the case of banks, leverage, capital adequacy and the funding structure are the most influential factors, together with income diversification. At the same time, the asset structure and the quality of the loan portfolio are not significant.

We continue our analysis by investigating cross-sector transmission channels of contagion and provide evidence of the existence of the asset-holding and guarantee channels for insurance companies. Using proxies of sovereign exposures, we document that insurance default risk and contagion are stronger when country default risk increases. We find also that insurers see the guarantee channel exacerbating the asset-holding channel: default risk and contagion increase for larger insurers with higher sovereign risk exposures and more non-insurance activities.

Our results, despite a different research design, are in line with Chen *et al.* (2013),[17] among others, finding stronger systemic risks in banks than in insurance companies. However, we are able to attribute systemic risks to both sectors to the specific channels through which it propagates and to the main features of entities' business models, more than in a binary specification (banks vs. insurers).

These findings raise questions on the proper regulatory approach to mitigate vulnerabilities of insurers to sovereign risks. We provide further evidence that size is a significant predictor of an insurer's exposure to systemic risks, in particular those arising from sovereign exposures and non-traditional activities.

Also for banks we document that default risk and contagion are higher when country default risk is stronger. This suggests that banking regulation should increase its focus on portfolio diversification, in particular on the home bias and the potential arbitrage involving sovereign risks. We also find that the collateral channel enhances the asset-holding channel: banks with more trading activities and reliance on short-term funding are more exposed to contagion.

Finally, the guarantee channel for banks is not significant in transmitting contagion to the insurance sector, probably because sampled banks are all significant in terms of size and interconnectedness.

Our findings are based on a limited number of entities, in particular insurers, despite they represent the whole population of systemic players with highly liquid CDS. This allows us to derive results that are limited to such institutions. In terms of policy implications, we support and extend the debate on similarities and differences between the insurance and the banking sector within systemic risk and contagion frameworks and in the light of recent re-regulations of financial institutions.

Moreover, our results suggest that supervisory actions addressing contagion risks should consider specific channels of propagation, cross-industry links and business models that seem to relate closely with systemic risks. This may involve further weighting of costs and benefits of an enhanced prudential scrutiny where links are stronger or business models are more similar, and where asset concentration is higher, especially in sovereign bond portfolios. In the case of banks, the collateral channel reinforces the role played by liquidity requirements and short-term funding. Finally, the guarantee channel and the role played by insurers' size and interconnectedness calls for additional analysis on potential convergence paths for cross-industry resolution mechanisms.

Suggestions for future research are twofold. On one side, a different methodological approach is required in order to extend the sample size and to allow further segmentation of the population of investigated entities. On the other side, the financial sector keeps encompassing substantial changes, in particular deleveraging and refocusing on core businesses through sale of assets (among others, examples are AIG, MetLife, Assicurazioni Generali), that will be able to influence the behaviour of cross-sector and cross-country systemic risk.

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