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On the exposure of insurance companies to sovereign risk – portfolio investments and market forces

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Non-technical summary

Research Question

In the course of the European sovereign debt crisis, sovereign risk has become one of the biggest threats to financial stability. We focus on the vulnerabilities of the insurance sector and investigate the following questions: Is domestic sovereign risk transmitted to insurers' default risk? Are insurers affected differently by sovereign risk than other sectors of the economy (i.e. banks and non-financial firms)? What drives the link between sovereigns and insurers?

Contribution

Despite the importance of insurance companies as financial markets participants, research on risk spillovers between sovereigns and the financial system have usually sidestepped the insurance sector. In our paper, we aim at contributing to a better understanding of transmission of sovereign risk to the insurance sector. Moreover, this is the first paper to empirically investigate the role of sovereign bond holdings in this context as well as alternative channels of risk transmission.

Results and Policy Implications

We find that domestic sovereign risk significantly increases insurer risk as perceived by markets. While this risk transmission is slightly smaller than for banks, it is substantially larger than for non-financial companies. We find that the difference to non-financial firms is due to insurers' large sovereign bond portfolios. These investments play a major role in risk transmission domestically as well as internationally through foreign sovereign exposures. Moreover, we document a bias towards domestic sovereign bonds and increasing concentration in European insurers' sovereign portfolios. The link to domestic sovereigns was stronger for those insurers that are classified as systemically important by the Financial Stability Board.

Overall, our results suggest that risks arising on the asset side of insurers' balance sheets deserve greater attention. Market expectations of insurer default risk depend on the riskiness of the sovereign debt portfolio of the insurer. However, in many cases, insurance regulation, including the new Solvency II regulation in the EU, exempts domestic government bonds from the calculation of the solvency capital requirement.

Nichttechnische Zusammenfassung

Fragestellung

Im Zuge der europäischen Staatschuldenkrise hat sich das Ausfallrisiko von Staaten als bedeutendes Risiko für die Finanzstabilität herausgestellt. Wir betrachten die Verwundbarkeiten des Versicherungssektors und untersuchen dabei folgende Fragen: Wirken sich die Ausfallrisiken eines Staates auf die Ausfallrisiken der Versicherer aus? Sind Versicherer davon anders betroffen als andere Wirtschaftssektoren (d.h. Banken und nicht-finanzielle Unternehmen)? Was bestimmt die Verbindung zwischen Staaten und Versicherern?

Beitrag

Die Forschung hat die Rolle des Versicherungssektors bei der Übertragung von Risiken zwischen Staat und Finanzsystem bislang kaum berücksichtigt. Dabei sind Versicherer große institutionelle Investoren und investieren einen bedeutenden Teil ihrer Aktiva in Staatsanleihen. Dieses Papier soll zu einem besseren Verständnis der Übertragung von Staatenrisiken auf Versicherer beitragen. Dafür werden verschiedene Übertragungskanäle empirisch untersucht.

Ergebnisse und Politikimplikationen

Unsere Ergebnisse zeigen auf Basis von Marktpreisdaten, dass Ausfallrisiken eines Staates die Ausfallrisiken der heimischen Versicherer signifikant erhöhen. Dabei ist die Risikoübertragung etwas geringer als für Banken, aber erheblich größer als für nicht-finanzielle Unternehmen. Der Unterschied zu nicht-finanziellen Unternehmen lässt sich auf die Staatsanleihen-Portfolios der Versicherer zurückführen. Diese Portfolios spielen eine wichtige Rolle für die Risikoübertragung sowohl im Inland als auch international. Weiterhin zeigt sich, dass die Staatsanleihen-Portfolios europäischer Versicherer stark auf den Heimatstaat konzentriert sind. Die Verknüpfung mit dem Ausfallrisiko des Heimatstaats war stärker für Versicherer, die vom Finanzstabilitätsrat als systemrelevant eingestuft werden.

Insgesamt legen unsere Ergebnisse nahe, dass Risiken auf der Aktivseite der Bilanzen von Versicherern stärker beachtet werden sollten. Ausfallrisiken im Staatsanleihen-Portfolio schlagen sich in der Markteinschätzung des Ausfallrisikos der Versicherer nieder. Trotzdem sind heimische Staatsanleihen in der Regulierung des Versicherungssektors oftmals von den Eigenmittelanforderungen ausgenommen, auch Anleihen von europäischen Staaten unter den künftigen Solvency II-Regeln.

BUNDESBANK DISCUSSION PAPER NO 34/2015

On the exposure of insurance companies to sovereign risk - portfolio investments and market forces[1]

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Abstract

A sovereign debt crisis can have significant knock-on effects in the financial markets and put financial stability at risk. This paper focuses on the transmission of sovereign risk to insurance companies as some of the largest institutional investors in the sovereign bond market. We use a firm level panel dataset that covers large insurance companies, banks and non-financial firms from nine countries in the time period January 1st 2008 to May 1st 2013. We find significant and robust transmission effects from sovereign risk to domestic insurers. The impact on insurers is larger than for non-financial firms and slightly smaller than for banks. We find that systemically important insurers were more closely linked to the domestic sovereign. Based on European data, we show that risks in sovereign bond portfolios are an important driver of insurer risk, which is not reflected in current insurance regulation (incl. upcoming Solvency II in Europe).

Keywords: insurance, sovereign risk, sovereign bond portfolio

JEL-Classification: G22, G28, G15

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1 Introduction

Since the outbreak of the European sovereign debt crisis, sovereign risk has been one of the main threats to financial stability. Many recent research papers investigate the link between sovereign risk and the banking system. In contrast, research on the effects of sovereign risk on insurance companies is very scarce. This is surprising, given the importance of insurance companies as large institutional investors in sovereign bond markets. Insurers hold roughly 12% of all global financial assets (IAIS (2011)) and they invest a major share of these assets in sovereign bonds (see JP Morgan Cazenove (2014)). To the best of our knowledge, our paper is the first to empirically analyze the channels of risk transmission from sovereigns to insurers.

Our analysis is based on a novel panel dataset that covers sovereigns, insurance companies, banks and non-financial firms from nine countries (Belgium, France, Germany, Italy, Japan, Netherlands, Switzerland, United Kingdom, and United States) over the time period from January 1st 2008 to May 1st 2013. We analyse the market expectation of default risk by using CDS spreads as our baseline risk measure. In our empirical methodology, we control for reverse causality and identify several channels of risk transmission.

We find that there is a strong and very robust transmission of default risk from sovereigns to domestic insurers. This risk spillover is slightly smaller than for banks but stronger than for non-financial companies. We take a closer look at the channels of risk transmission using portfolio data for European insurers as provided by JP Morgan Cazenove (2014). JPMorgan regularly publishes estimates of sovereign bond holdings of 17 large European insurers (see Annex for a list of insurers). These data are based on the financial reports by the insurance companies and are available quarterly since Q4 2009 through Q1 2013. We expect that the default risk of insurers increases with the higher default risk of sovereign bonds during the European debt crisis. At the same time, however, insurance companies may benefit from the higher yields on new investments into risky sovereign debt, especially in the current low interest rate environment. Ex ante, it is thus unclear whether the risk or return effect of sovereign bonds dominates. Our results suggest that the risk effect was more important than the return effect in the sovereign bond portfolios of large European insurers in our sample period. We find that the default risk of insurers is driven by the riskiness of their sovereign bond portfolios. These portfolios explain the higher vulnerability of insurers relative to non-financials. We document that diversification in sovereign bond portfolios is low and has been declining in recent years.

Also, insurers that have been classified as systemically important financial institutions (SIFI) by the Financial Stability Board (FSB) were more closely linked to domestic sovereign risk during our sample period.

Furthermore, we find that sovereign risk transmission increases with the level of sovereign risk and has been stronger in the euro area than elsewhere. Over time, however, we see little heterogeneity in the transmission of sovereign risk to domestic insurers.

Finally, risk in the domestic banking sector also significantly increases default risk of insurance companies.

Our findings are important for policymakers, regulators and the industry alike. The identified portfolio channel has important implications for supervisory monitoring and the design of regulation. So far, domestic sovereign bond investments are generally exempted from capital charges in insurance regulation. Under the new European insurance regulation Solvency II, which comes into effect in 2016, EU sovereign bonds are exempted from the risk modules for the calculation of solvency capital requirements under pillar 1. Thus, regulation treats domestic (and EU) sovereign bonds as if they were risk free for insurance companies. We show that markets however take risks in the sovereign bond portfolios into account when assessing default risks of insurers.

From a macroprudential perspective, the stability of insurers is of interest because insurance companies pool and allocate risks in the economy, thereby contributing to financial stability. Moreover, given its importance as a large institutional investor, distress in the insurance sector can destabilize the financial system (International Monetary Fund (2015)).

Given this importance, it is surprising that research on the vulnerability of insurers to sovereign risk is very scarce. The only paper known to us that includes insurance companies as part of the nexus between sovereigns and the financial system is Billio, Getmansky, Gray, Lo, Merton, and Pelizzon (2013). Based on Granger causality and network analysis, they find that the system of banks, insurance companies, and sovereigns is highly dynamically connected. They do not, however, discuss the channels of risk transmission, which is what we do in this paper.

The literature on risk spillovers between sovereigns and the private sector focuses almost exclusively on (i) banking or (ii) (non-financial) firms. We take this as a starting point for our hypotheses and add an insurance-specific view.

Spillovers from sovereign risk to banks have been documented in several recent studies since the outbreak of the European sovereign debt crisis (see, for example, Acharya, Drechsler, and Schnabel (2014), Altera and Schüler (2012), Battistini, Pagano, and Simonelli

(2013)).[2] Two main channels of transmission have been identified. For one, a large number of studies have found that the expectation of government bail-outs led to a robust link between the credit risk of key financial intermediaries and the domestic sovereign (e.g. Acharya et al. (2014), Correa, Lee, Sapriza and Suarez (2014), Noss und Sowerbutts (2012)).
Second, banks are vulnerable to sovereign risk due to their sovereign bond portfolio (Buch, Kötter, and Ohls (2013), De Bruyckere, Gerhardt, Schepens, and Vander Vennet (2012)). This can stem from the risk of incurring direct losses on bond holdings as well as from the importance of sovereign bonds as collateral to obtain funding.

In the case of insurers, we expect bond holdings as a transmission channel to be pivotal. Our data suggest that insurers hold a larger share of their assets in sovereign bonds than banks (for Europe the numbers are roughly 20% and 11%, respectively).[3] Moreover, anecdotal evidence suggests that the (domestic) sovereign bond investments of insurers are particularly large and increasing in countries that suffer from sovereign stress. Italian insurers, for instance, increased their exposure to Italian public debt from 33% of their total asset portfolio in 2008 to 50% of their portfolio at the end of 2012.[4] In this study, we therefore focus on the impact of the sovereign bond portfolio on risk transmission.

It should be noted, however, that insurers differ from banks in their funding structure. Insurers are prefunded as they receive regular payments from insurance customers and are therefore less reliant than banks on sovereign bonds as collateral for funding operations. Insurers impose costs on their customers for terminating an insurance policy and are hence less prone than banks to liquidity runs.[5] Insurance companies may need collateral for hedging operations such as interest rate swaps, however. Overall, direct losses in the market value of their sovereign portfolio should pose the largest risks to insurance companies.

Spillovers of sovereign risks to the non-financial sector have also been analyzed. Rises in sovereign risk are often closely associated with a difficult macroeconomic environment and reduced domestic demand, which, in turn, impairs private firms' earning opportunities and increases their probability of default (see, for example, Ciocchini (2002), Durbin and Ng (2005)). Moreover, Acharya et al. (2014) argue that sovereign default risk increases the expected tax burden, which, in turn, reduces firms' profitability and investment. Based on

[2] For the sake of completeness, it should be mentioned that several studies analyze contagion from banks to the sovereign through, say, bank bail-outs (Gerlach, Schulz und Wolff (2010), Alter und Beyer (2014), International Monetary Fund (2011)).
[3] For European banks, see EBA (2011), for insurers, see JP Morgan Cazenove (2014).
[4] See speech by Aldo Minucci, head of Italy's insurance association ANIA (Bloomberg news, 2.7.2013.).
[5] Under certain circumstances, terminations of insurance contracts on a large scale cannot be ruled out completely, however. See for example Feodoria and Förstemann (2015).

these findings, we will control for the macroeconomic environment in our analysis. Also, by explicitly comparing the vulnerability of insurance companies with that of other private sector firms, we eliminate effects common to all firms.

Before turning to the empirical approach, we first look at the mere correlation of sovereign risk and insurer risk and find that both sectors tend to move together (see Figure 1). The blue (red) line gives the average 5-year CDS spread of the insurance companies (the sovereign) as taken from the data provider Markit (in basis points).

Figure 1 CDS spreads of Insurers and Sovereigns

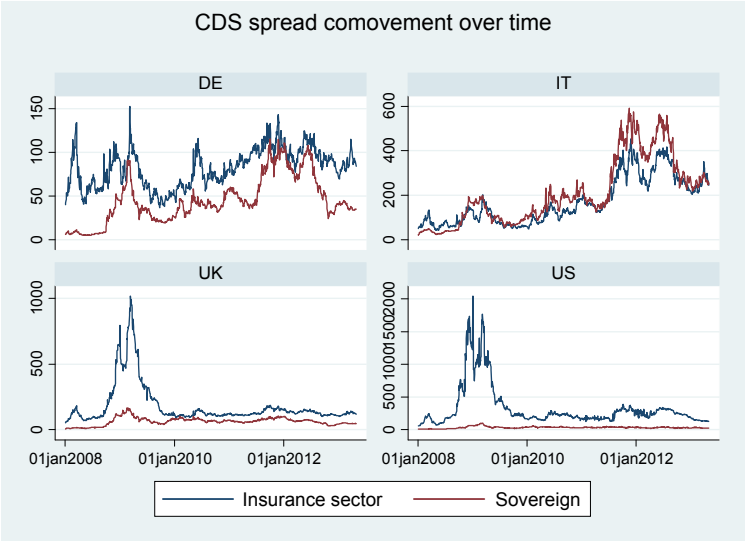

Figure 1 shows the movement of CDS spreads of the insurance sector (blue) and the sovereign (red) in Germany, Italy, UK, and US in the time period January 1st 2008 to May 1st 2013 in basis points (Source: Markit).

While Figure 1 gives a first hint at a relationship between sovereign and insurer risk, this finding might be driven by different factors that affect both sovereign and insurer risk simultaneously. We will address these concerns in our empirical strategy.

First, we estimate a reduced form equation of insurer risk on sovereign risk, controlling for a number of confounding factors (following estimation by Acharya et al (2014) for an application in the banking case). To address the issue of whether we identify a causal and insurer-specific effect of the transmission of sovereign risk, we perform a number of additional checks. We compare the magnitude of transmission across sectors (as in Bühler and Prokopczuk (2010)), control for reverse causality through Instrumental Variable regression (as in Bedendo and Colla (2013)) and identify transmission effects through an institution-specific measure of exposure ("identification through heterogeneity").

The paper is structured as follows. In Section 2, we discuss our hypotheses on transmission channels of sovereign risk to insurer risk. Section 3 presents the dataset and our empirical

strategy. In Section 4, we present the results. Section 5 concludes and offers policy implications.

2 Hypotheses on risk transmission channels

To the best of our knowledge, there is no theoretical model to guide our hypotheses on the relationship between sovereigns and insurance companies. Instead, we build on the findings of the related literature on banks and non-financial firms presented above and add an insurance specific view. We consider several transmission channels from sovereign risk to insurers' risk in our empirical setup:

1. Insurers are highly exposed to sovereigns through their bond holdings. An overview of the asset side of European insurers' balance sheets is published in the reports of the European Insurance and Reinsurance Federation. These reports show that 42 % of assets are invested in debt securities and other fixed-income assets, 31 % are shares and other variable-yield securities, and 11 % are loans[6] (Insurance Europe (2014)). Life insurers are by far the most important players in terms of assets and thus feature prominently in our sample. Life insurance companies often have long-term nominal liabilities. To achieve duration matching, these are best matched by long-term, low-risk bonds, which "guarantee" a fixed nominal return. This, supported by a preferential regulatory treatment, has led many insurance companies to heavily invest in government bonds (Wilson (2013)).

According to Ernst & Young, the majority of insurers' sovereign bonds (over 60%) are classified as "available for sale" (Ernst & Young (2011)).[7] This is because they are held as a liquidity buffer with the option of selling them before maturity. Given current accounting rules (i.e. IAS 39 - Financial Instruments), this implies that movements in the price of sovereign bonds will directly affect the insurers' capital position. Therefore insurer default risks can be expected to increase with the riskiness of their sovereign portfolios (see also Bank of England (2014), Ellul, Jotikasthira, Lundblad & Wang (2014)). Sovereign risk would thus affect insurers through a **portfolio channel.** We will study this channel by including company-level information on insurers' sovereign bond holdings.

There is a trade-off between risks and returns of sovereign bonds. If higher risks are compensated by higher returns, the impact of new purchases of sovereign bonds on insurers' default risks is ambivalent. Especially life insurers have in some jurisdictions issued fixed

[6] The remainder is composed of investments in affiliated undertakings and participating interests, deposits with credit institutions, land and buildings, and other investments.
[7] This view is supported by Impavido and Tower (2014), p. 18.

nominal interest rate guarantees, which they struggle to earn in the current low interest rate environment (Kablau and Weiss (2014)). As we base our analysis on the market expectations of insurers' default risks. The trade-off between risks and returns should have been priced in and the estimated coefficients should thus give the net effect of the risk and return effects.

2. **Risk transmission from the banking system** to insurance companies might also play a role. Our portfolio data suggests that exposure to bank debt is similar in size to exposure to sovereigns. A number of earlier studies find that insurers are affected by bank risk (Bernoth and Pick (2009), Hammoudeh, Nandah, and Yuan (2013), Chen, Cummins, Viswanathan, and Weiss (2014)). We control for the banking channel by including a measure for domestic banking system risk. There is some indication that risk spillovers also transmit from insurers to banks (Podlich and Wedow (2013)). We will take this potential endogeneity into account by using instrumented variables regression as a robustness check (see Section 4). The banking channel might capture part of the (indirect) transmission of sovereign risk to insurers, as banks are also highly exposed to the sovereigns themselves. This common exposure of insurers and banks to their domestic sovereign may reinforce risk transmission beyond direct holdings of sovereign bonds by insurers.

3. **Government guarantees** for insurance companies or insurance guaranty funds[8] might generate spillovers from sovereign risk to insurers. If a government guarantees to rescue an insurance company (or is expected to do so), the perceived risk for insurers grows if the risk of sovereign default increases, i.e. the bail-out capacity decreases. We will show results supporting market expectations of government guarantees for insurers that have been declared systemically important by the FSB, but not for all insurers. While this is a plausible result, we are unable to provide a direct test for government guarantees. Such a test would require data on market expectations of bail-outs, which are unavailable to us, and is therefore left to future research.

4. **Insurance regulation** can alter the incentives for investing in sovereign bonds and thus change insurers' vulnerability to sovereign risk through the portfolio channel. In most countries in our sample, the Solvency I framework is applied, which does not envisage capital requirements for holding financial assets, including government bonds (e.g., Belgium, France, Germany, Italy).[9] Some sample countries have introduced additional requirements, which

[8] Insurance guarantee funds step in to pay the covered claims of policyholders of an insolvent insurer, similar to a deposit insurance system.
[9] Capital requirements would generally depend on the volume of premiums, technical provisions or incurred claims.

augment the Solvency I regulations (Netherlands, United Kingdom). Finally, there are countries, which have introduced risk-based capital requirements (Switzerland, Japan, and United States). However, in these countries sovereign bonds are generally also excluded from both capital requirements and diversification requirements.[10] In Europe, a new regulatory framework, Solvency II, will be introduced in 2016. Under Solvency II, all assets of insurance companies, including their holdings of sovereign bonds, will have to be marked to market. Thus, the Solvency II balance sheet will reflect the expected value of insurer's assets and liabilities. In addition, insurers will have to hold capital to be able to cover unexpected losses from different risk categories (e.g. spread and concentration risks).[11] However, sovereign bonds issued by the government (or central bank) of a EU member state will be exempted from capital requirements for spread and concentration risks. Moreover, Thibeault and Wambeke (2014) show that an investment into long term EU government bonds could even lead to a marginal decrease in capital requirements, if the overall interest rate risk which stems from a duration mismatch of assets and liabilities is decreased by this investment. The standard formula for the calculation of the Solvency Capital Requirement (SCR) under Solvency II thus does not require capital buffers against the risk of holding EU sovereign bonds.[12] Our results question this assumption, as insurers are affected by the riskiness of their sovereign portfolios according to market perceptions.

3 Dataset and Empirical Strategy

We construct a panel data set with information on credit default risk of firms from different industries across the world. It covers insurance companies, banks, and non-financial firms from nine countries (Belgium, France, Germany, Italy, Japan, Netherlands, Switzerland, United Kingdom, and United States) for the time period January 1st 2008 to May 1st 2013.

Our dataset includes all types of insurers (life, reinsurance, health, property, etc.) except insurers that provide financial guarantees (e.g. AIG, MBIA). The latter have a very special business model which focuses on "non-traditional insurance activities", such as bond insurance. The transmission of sovereign risk is therefore likely to work differently for these firms and would not be covered adequately by our focus on traditional insurance companies'

[10] At least those issued by OECD countries and especially those issued by the domestic sovereign, which is our focus. In Switzerland, claims against AAA-rated sovereigns are exempt from diversification requirements.
[11] The solvency capital requirement is calibrated such that it reflects the Value-at-Risk at 99.5% quantile.
[12] Under pillar 2 of Solvency II, however, insurance companies will still have to assess their overall solvency needs related to their specific risk profile (Own Risk and Solvency Assessment (ORSA)).

business models. Excluding the financial guarantee insurers reduces the sample size from 48,630 to 41,611. The resulting sample includes 29 insurance companies and 1,379 trading days (unbalanced sample). To make sure only prices of frequently traded CDS are used in the analysis, we exclude any company that reports CDS values for less than three years over our sample period (750 trading days).[13] This reduces our sample further to 37,078 observations. Due to missing control variables, our final sample comprises 34,683 observations (insurance companies=29, days=1379). We also collect CDS data for banks and non-financial corporations for the above countries. This increases our sample size to 396 private sector firms from ten industry sectors and 1,379 trading days.[14]

Table 1 contains summary statistics on the variables of our different estimation samples. All in all, our estimation sample is quite similar to the overall sample.

As a baseline, we regress risk in the insurance sector on home sovereign risk. This yields Equation (I).

$$\Delta \ln(risk_{ins,t}) = \beta_0 + \beta_1 \Delta \ln(risk_{sov,t}) + \beta_2 \Delta ln X_{jt} + \varepsilon_{ins,t} \quad \text{(I)}$$

where $risk_{ins,t}$ is a measure of insurer performance at time t, $risk_{sov,t}$ the domestic sovereign risk, and X_{jt} is a matrix of country-specific control variables. We control for growth (expectations), risk aversion in financial markets, counterparty risk in the CDS market and risks in the national banking system. All variables are measured daily and in changes of their logs $\Delta \ln(.)$. The log transformation allows us to interpret the coefficients as elasticity, a measure of sensitivity that is independent of the scale of our risk measure. That is to say, the coefficient captures the percentage increase in insurer risk for a 1% increase in the independent variable.

Our baseline empirical strategy follows the approach of Acharya et al. (2014) in their study on banks and sovereign risk. In this baseline specification, our independent variables vary at the country-time dimension only. Time-invariant insurer characteristics have been eliminated by the first difference transformation. In an augmented specification (II), which is described below, we allow the independent variable to vary at the insurer level and can thus control for country-time fixed effects.

[13] We also collect data on the trading volume of each insurer CDS used. This confirms that our risk measure is based on a highly liquid market.

[14] We distinguish between the sectors insurance, banks, basic material, consumer goods, consumer services, energy (including oil and gas), healthcare, industrials, technology and telecommunications as classified by the data provider Markit.

Dependent Variable

We use two alternative measures of performance for $risk_{ins,t}$: CDS spreads with five-year maturity from Markit and stock returns from Bloomberg. CDS spreads measure default risk and are the standard in the recent literature (Longstaff, Pan, Pedersen, and Singelton (2011), Acharya et al. (2014)).[15] These papers discuss two main reasons for choosing CDS spreads in lieu of bond spreads: They better reflect risks, as CDS are designed to insure against default risks and serve no other purposes that might drive their price. Moreover, the CDS market is more liquid than most bond markets. As our analysis seeks to uncover risk transmission at a relatively high frequency (daily and weekly data), liquidity is key. This is ensured by excluding all companies that report CDS values for less than three years over our sample period (750 trading days) as discussed above.

As a robustness check, we use a measure of insurer performance, namely stock returns. They reflect a broad set of developments, including default risk and profitability of an insurer. The advantage of stock returns is that they are more widely available and thus allow us to check whether our results hold more broadly. However, they include additional information that is unrelated to default risk.

One great advantage of both market-based performance measures over balance sheet data is that they capture ex ante anticipated risk exposures and are available at a high frequency. Balance sheet measures would only reflect realized risks ex post. However, our measures only capture risks that are correctly priced by the markets. We thus do not seek to uncover hidden risks, but rather highlight how risk passes from the sovereign sector to insurers based on market expectations.

Independent Variables

Our variable of interest is $risk_{sov,t}$ measured by domestic sovereign CDS with five-year maturity drawn from Markit.

As control variables we include country-specific measures for economic performance, market confidence and banking risk. A proxy for economic activity and growth in the estimation is the national stock market index (drawn from Bloomberg). Both insurers

[15] We select USD-denominated CDS quotes from the Markit group with five-year maturity for senior unsecured debt with the modified-modified restructuring clause for financial and non-financial firms and the cumulative restructuring clause for sovereigns. These represent the conventional and most liquid terms for CDS contracts on European reference entities, which will be the focus of our analysis. See also Bedendo and Colla (2013) and Bai and Wei (2012).

(through loss events and premium income) and sovereigns (through tax income and social expenditures) are influenced by real economic activity. Hence, it is important to control for growth in order to avoid an omitted variable bias. Market sentiment and risk aversion are measured by the implied volatility on the national stock indices over 30 days, e.g. VDAX-NEW for Germany and VIX for United States (drawn from Bloomberg).[16]

To control for risks emanating from the banking sector we take the weighted average of the CDS of domestic banks, where we weight each bank by its relative size in the country.[17]

The current low interest rate environment poses a challenge for (life) insurer solvency, especially if the insurer promised fixed nominal interest rates to policyholders (IMF (2015), Kablau and Weiss (2014)). Typically, the vulnerability of insurance companies depends on the level of interest rates as well as on differences in the business model of life insurers. Therefore, we control for structural differences between insurers in e.g. asset-liability-management by estimating all specifications in log changes. Also, we include time fixed effects that capture the common decrease in interest rates across advanced economies during our time period. In an augmented specification we include country-time fixed effects, these also capture time-varying differences in business models of insurers between countries. [18]

Econometric Issues

Since our data contain a substantial time series component, we check for stationarity and find no evidence of unit roots in first differences.[19]

We also check for autocorrelation in our standard errors, but find little evidence of this.[20] Our baseline regression does not control for auto correlation; however, results are unaffected if we do so.[21] Apart from correlation of shocks across time, there might be concerns about correlation of shocks between firms during the same time period. To take this into account,

[16] For Belgium, we were unable to obtain any national volatility index, which is why we take VSTOXX in this case.

[17] Size is measured by total assets. CDS spreads are taken from Markit with five-year maturity in national currency.

[18] For example, the duration gap of assets and liabilities varies substantially between insurers in different European countries. On average, German insurers have the largest duration gap, while assets and liabilities of UK insurers are matched quite well (EIOPA, 2014).

[19] We perform the Fisher unit root test for heterogeneous mixed panel data. This assumes that there is no cross-sectional dependence in the dataset. We do not have independent cross sections, as several insurance companies are from the same country and therefore related and exposed to common shocks. In order to mitigate this problem we demean our time series as suggested by (Levin, Lin, and Chu (2002)).

[20] The autocorrelation in the errors is below 0.2 and insignificant from the second lag onwards in all time series.

[21] As a robustness check, we allow for autocorrelated errors of up to one month (i.e. 20 trading days) (see Driscoll (1998)). Results remain practically unchanged (results are available upon request).

we allow shocks to be correlated contemporaneously by clustering standard errors on the time dimension.

Another econometric concern might arise in the presence of reverse causality. Equation (I) is a reduced form regression, which only yields the "true" causal effect of sovereign on insurers if there is no reverse causality, i.e. no effect of insurance companies on sovereign and banking system risk. There are a number of a priori reasons why one would not expect reverse causality to be a concern in this specific context.

First, traditional insurance companies have not featured prominently in the debate about government solvency. The insolvency of Equitable Life (UK, in 2000), for instance, is seen as an example of how policyholders can in fact incur considerable losses without a subsequent need for state intervention. Empirically, Billio et al. (2013) provide evidence on the Granger causality relations between sovereigns, banks and insurers, suggesting that the predictive power of insurer to sovereign is far weaker than the opposite relation from sovereigns to insurers.

Second, our dependent variable is on the micro level. We consider individual insurance companies which are less likely to impact the macro level, such as the overall banking system and the sovereign.

Also, we use the heterogeneity on the company level to identify the effect of sovereign risk (identification through heterogeneity). In Equation (II), we introduce the interaction effect between the company-specific portfolio exposure to the national sovereign and sovereign CDS and the results still hold.

Finally, we perform instrumental variables regressions to test the robustness of our results. Following Bedendo and Colla (2013), we use average foreign sovereign risk as the instrument for domestic sovereign risk and, similarly, foreign banking system risk as the instrument for domestic bank risk. This eliminates the concern that our observed link between insurers and sovereigns is due to implicit guarantees by their home governments. Our instrument is the average of the risk in the largest sovereign bond markets and banking systems.[22] Foreign risks are correlated with domestic risks due to contagion effects on the sovereign and banking CDS markets respectively. Regarding the exogeneity of the instruments, an individual insurer is very unlikely to have market power and thus influence prices in the most widely traded bond markets. General market risk sentiments or shocks to global economic output might impact

[22] For sovereign bonds, these are US, JP, DE, IT, FR, UK, ES, CA, NL, KR. For foreign banking systems, we take the largest non-developing country banking systems, which are in US CA BE CH DE FR UK IT NL ES JP AU.

foreign sovereign risk and insurer risk simultaneously. Therefore, we will explicitly control for stock index volatility and stock index development to capture these common factors. Furthermore, we will use formal statistical tests on the relevance and the exogeneity of instruments, which are reported in the results Sub-section 4.1.

Testing for transmission channels

In order to analyse the transmission channels, we introduce additional variables in Equation (I). The portfolio channel is measured by the domestic sovereign bond holdings relative to total assets of an insurance company weighted by the riskiness of the domestic sovereign. In a second step, we introduce a measure for overall sovereign portfolio riskiness (home and foreign portfolio). It weights each sovereign CDS with its relevant sovereign share in the insurer's portfolio, i.e.

$$Riskiness\ of\ sovereign\ portfolio = \sum_{all\ sovereigns\ j} \frac{sovbonds_{ijt}}{totalassets_{it}} * CDS_{jt}.$$

This yields Equation (II):

$$\Delta \ln(risk_{i,t}) = \beta_0 + \beta_1 \Delta \ln(risk_{sov,t}) + \beta_2 \Delta lnX_{j,t} + \beta_3 \frac{sovbonds_{i,sov,t}}{totalassets_{i,t}} \Delta \ln(risk_{sov,t})) + \frac{sovbonds_{i,sov,t}}{totalassets_{i,sov,t}}$$
$$+\beta_4 \sum_{all\ sovereigns\ j} (\frac{sovbonds_{i,j,t}}{totalassets_{i,t}} * \Delta \ln(risk_{j,t})) + \varepsilon_{i,t} \quad \text{(II)}$$

where the subscript sov denotes the domestic sovereign and j all other sovereigns. All other variables and econometric specifications are equivalent to those in Equation (I). The new measure of portfolio risk here is institution-specific. This will allow us to control for country-specific time effects in a robustness check.

Since we analyze market behaviour, we use the market estimate of the exposure of an insurer as provided by JPMorgan (J.P.Morgan Cazenove (2014)) rather than administrative data. JPMorgan regularly publishes estimates of sovereign bond holdings of 17 large European insurers (see Annex for a list of insurers). These data are based on the financial reports by the insurance companies and are available quarterly since Q4 2009 through Q1 2013.

In order to test for the international transmission of sovereign risk, we separate the overall sovereign portfolio into their domestic and the foreign parts, constructing the riskiness of both parts of the portfolio separately.

Finally, we create a dummy SIFI that differentiates between insurers that have been classified by the Financial Stability Board (FSB, 2013) as systemically important and those who have not. We will test whether transmission of sovereign risk is the same for both groups.

4 Estimation and results

4.1 Does sovereign risk transmit to risk in insurance?

Table 2 reports the results of estimating specification (I). In column 1 we estimate Equation (I) without any controls. The coefficient thus reflects the correlation between insurance risk and its domestic sovereign. We find a highly significant positive elasticity. A 10% rise in sovereign risks leads to a roughly 2% rise in risks in the insurance sector. Column 2 controls for the national volatility index and stock market movements. The coefficients on the volatility index (stock market index) show the expected positive (negative) sign and decrease the effect of sovereign risk.

In column 3 we additionally control for the risk in the banking sector. Including the banking sector has two effects. First, as discussed above, the banking sector could be an omitted variable, which needs to be introduced for correct estimation. But, at the same time, the domestic banking system might also be an indirect transmission channel from sovereigns to insurers, as discussed in Section 2. Therefore, the estimated direct impact of home sovereign CDS on insurer CDS (=0.067) in column 3 can be interpreted as a lower bound of the total impact. Some transmission of sovereign risk to insurers might be captured by the banking channel due to the common exposure of banks and insurers to sovereign risk, as well as to other asset classes. Also, bank bonds are roughly as important in the balance sheet of insurers as sovereign bonds (JP Morgan Cazenove (2014)). Indeed, we find that the stability of the domestic banking system is important for insurer stability. A 10% increase in banking risks increases default risks of a domestic insurer by 4%. This finding is in line with previous studies, which found transmission of banking risk to the insurance sector (Bernoth and Pick (2009), Hammoudeh, Nandah, and Yuan (2013), Chen, Cummins, Viswanathan, and Weiss (2014)). We will control for potential endogeneity between insurer and banking system CDS with Instrumental Variables estimation.

In column 4 we use time-fixed effects to absorb factors that are common to all insurers. What remains is a conservative estimate of risk contagion from the sovereign to the domestic insurer, as the average transmission at a given date will be absorbed by the time-fixed effects. As expected, the elasticity decreases further in economic terms. However, even at this lower bound, the elasticity remains significant at the 1% confidence level.

These findings prove robust to a number of different specifications. We perform the above regression in level changes rather than log changes and using weekly data instead of daily quotes (not reported). These results are in line with what we report above. Furthermore, we

use an alternative dependent variable, namely stock returns as a measure of the performance of insurance companies. We estimate equation (I) again with the log change of an insurer's stock price as the dependent variable. Results are reported in Table 3 and confirm our findings based on CDS spreads. An increase in domestic sovereign risk is associated with a decrease in the insurer stock prices. In this regression, we exclude the domestic stock index as an explanatory variable, as it often contains the respective insurer stock price as one element.

IV Estimation

To address endogeneity concerns, we perform instrumental variables regression, as described in the previous section, with foreign sovereign and banking CDS as instruments for domestic sovereign and banking risk respectively. Our instruments are relevant with highly significant F-statistics in first-stage regressions. Weak identification tests as proposed by Angrist and Pischke (2010) confirm the relevance of our instruments above the conventional threshold.

In order to formally test the exogeneity of our instruments we run an overidentification test. To be overidentified we include the interbank lending rate as an additional instrument.[23] The overidentification test is not rejected at the 5% significance level. We can thus be more confident that our IV estimates identify the transmission effect.

Table 4 reports the results of the instrumental variable regression. As in the OLS regressions, we find a strong and significant effect of domestic sovereign risk on insurers. This holds true if we introduce the interbank rate as an additional instrument (column 2).

One interesting finding is that the coefficient of interest on domestic sovereign risk increases in IV estimation relative to our OLS estimates: it is twice as large. At the same time, the effect of the banking system also increases, while the effect assigned to wider market developments substantially decreases.

The changes in coefficients relative to the OLS setting are in line with a negative effect of insurers on sovereigns and banks in the structural equation. This would imply our reduced form regression above *underestimates* the effect of sovereign risks on insurers. One interpretation is that insurers absorb risks by providing stable liquidity in times of market stress (see Bank of England (2014) for an illustration of this point).

[23] Since short-term liquidity is less of a concern for insurers, movements in this rate should not affect the solvability of insurers directly. It does, however, have large effects on the funding costs of banks and thus bank default risks.

4.2 Are Insurers Different From Banks and Non-financial Firms?

Sovereign default risk may create problems for any private sector firm, not just insurance companies. As discussed above, such risk spillovers may occur for a number of reasons. We would therefore like to know whether insurers are special when it comes to sovereign risk.

We re-estimate specification (I) for insurers, banks and non-financial firms from the same nine countries (Belgium, France, Germany, Italy, Japan, Netherlands, Switzerland, United Kingdom, United States) and over the same time period of January 1st 2008 to May 1st 2013. This increases our sample size to 396 private sector firms from ten industry sectors and 1,379 trading days.[24] We include all firms with non-missing CDS pricing data for at least three years. The sample composition comprises 7% insurance companies, 18% banks and 75% non-financial firms. As we include banks as a dependent variable, we no longer control for average banking system CDS on the right-hand side in order to avoid correlation by construction. Otherwise, the variables and definition remain the same as explained in Section 3 on data.

Table 5 reports the results of those regressions. In the pooled regression (column 1) the estimate of sovereign risk is about 0.09 and highly statistically significant. We thus conclude that there is risk transmission from the domestic sovereign to private firms in general. This average effect disguises substantial differences across industries, however. In column 2, we use insurance companies as a baseline category and introduce interaction effects between domestic sovereign risk and an identifier for banks and non-financial firms, respectively. Table 5, column 2 shows that risk transmission to non-financial firms is significantly lower than to the insurance sector. This finding is not driven by specific non-financial sectors. In column 3 we use a more detailed breakdown by sector and find that insurers are more affected than any non-financial sector.

Regarding the comparison of banks and insurers, evidence is weaker. We do not find a significant difference in the vulnerability of banks and insurers to sovereign risk in the worldwide sample. Only in the European sample, which starts in Q4 2009, do we find that banks are significantly more affected than insurers by domestic sovereign risk (column 4). The European sample will serve as a benchmark for the estimations in the next chapter on portfolio transmission, as we have portfolio data from JPMorgan for European insurers only. The latter result of the higher vulnerability of banks is in line with literature highlighting the

[24] We distinguish between the sectors insurance, banks, basic material, consumer goods, consumer services, energy (including oil and gas), healthcare, industrials, technology and telecommunications as classified by the data provider Markit.

importance of sovereign bonds for bank funding (see, for example, International Monetary Fund (2012), Correa, Lee, Sapriza, and Suarez (2014)). The fact that this vulnerability is not generally larger for banks than for insurers might reflect the fact that insurers rely on sovereign bonds as collateral as well.

All in all, we find that insurers take a middle position between banks and non-financial firms with regard to vulnerability to sovereign risk. The difference in the coefficient between insurers and non-financial firms is larger in magnitude and remains significant across more specifications than the difference between insurers and banks. In what follows, we try to analyze the additional transmission channels that explain this gap between insurers and non-financial firms.

4.3 Taking a closer look at risk transmission channels

In this section, we will test for the transmission channels of sovereign risk to insurance which were discussed in Section 2 and which may explain the greater vulnerability of insurers compared to non-financial firms. We start with a description of insurers' sovereign bond portfolios. Afterwards, we formally test the importance of the portfolio channel using the sovereign bond portfolio figures published by JPMorgan. These are only available for Q4 2009 – Q1 2013 and for 17 European insurers. We therefore perform the subsequent analysis with this reduced sample.

Descriptive Facts of Insurers' Sovereign Portfolios

Overall, sovereign bond investments play a sizable and increasing role in the balance sheets of European insurance companies, amounting to around 20% in Q1 2013 (see Figure 2). This is more than in the balance sheet of European banks (approx. 11 %[25]).

Interestingly, heterogeneity between countries is high. On the country level, the average importance of sovereign bonds is lowest for UK and Dutch insurers at an average of 10% of total assets and highest in Italy and Belgium at 35% of total assets. There is also within-country heterogeneity between insurers, which we use in the regressions.

[25] See EBA (2011).

Figure 2

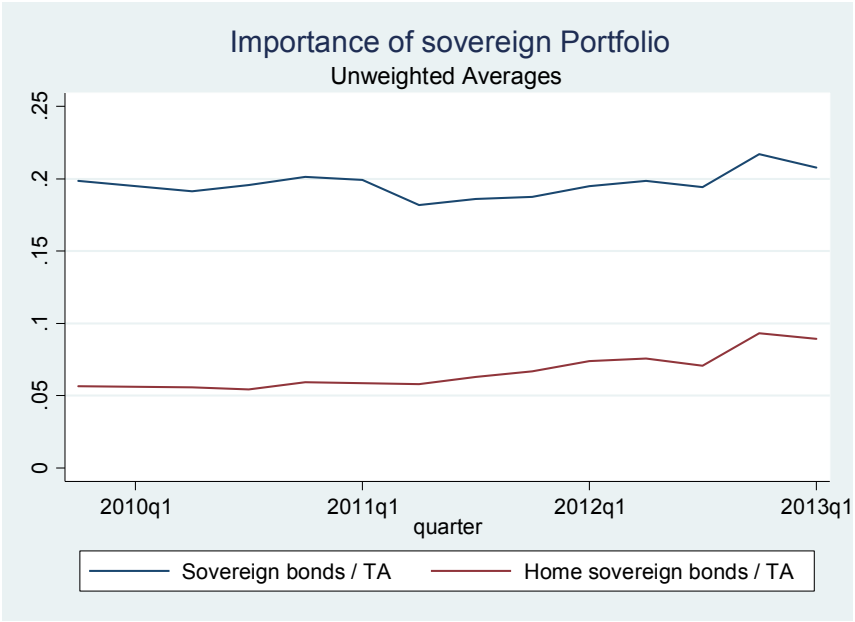

Figure 2: Share of sovereign bonds to total assets (blue line) and domestic sovereign bonds to total assets (red line) of the insurance companies in our sample (unweighted averages) in the time period October 1st 2009 to May 1st 2013 (Source: JP Morgan Cazenove, own calculations).

Regarding the composition of the sovereign bond portfolios, the importance of **home** sovereign bonds in insurers' balance sheets stands out (see Figure 2): With respect to the sovereign bond portfolio, domestic sovereign bonds are the most important item with a share of 37% on average. If there were no home bias in sovereign bond portfolios, we would expect the *average* share of domestic sovereign bonds to equal 1/number of sovereigns j = 1/11, which equals 9%. Taking unweighted averages across all countries should mitigate size effects of different countries, which could impact their weight in the sovereign portfolio. Studying the incentives for this home bias (37% actual portfolio weight of home sovereigns relative to 9% in the benchmark) might be an interesting avenue for future research. One reason might be asset-liability management with respect to currencies. Within the Eurozone, this would, however, not explain the predominance of a national instead of a euro area focus.

Given the strong home bias in the portfolios, we take a closer look at the diversification of insurers' sovereign bond portfolios. To measure portfolio concentration, we use the Herfindahl-Herschman-Index (HHI). The index is calculated as the sum of the squared shares of sovereign j in the total sovereign portfolio. In our case, the index can, in theory, range from 0.09 (perfectly diversified) to 1 (completely concentrated).[26] Throughout our sample period the average concentration index increased continuously from 0.29 in Q4 2009 to 0.4 in

[26] We have exposure information for 11 sovereigns; the HHI thus lies between 0.09 (equal shares for all sovereigns) and 1 (full concentration on only one sovereign)

Q12013. Also, heterogeneity is high as the HHI ranges between 0.2 (10% quantile) and 0.86 (90% quantile) in Q1 2013.

We will now address whether such investment behaviour affects risk transmission in the financial market.

Testing the portfolio channel

To estimate the effect of the riskiness of the portfolio on insurer default risk we estimate Equation (II). Table 6, column 1 shows that the effect of domestic sovereign risk on an insurer increases with the domestic sovereign bond holdings of this insurer. In order to assess the economic magnitude of the portfolio channel, we compare an insurer with high domestic sovereign bond holdings (i.e. which is at the 75% quantile of the distribution of "domestic sovereign bonds over total assets") to an insurer at the 25% percentile of the same distribution. We find that the insurer with high sovereign bond holdings suffers an additional 5% rise in its CDS for the same 10% increase in sovereign risk.[27] This is large compared to the baseline effect, which amounts to a 1.3% rise in insurer CDS for a 10% increase in sovereign risk. Hence, we find the portfolio channel to be statistically and economically significant.

In column 2 we include country-time fixed effect. The fixed effects capture the unconditional effect of sovereign risk on domestic insurers, but the interaction effect with the insurer specific bond exposure can be estimated. Importantly, the portfolio channel remains significant. This specification explicitly identifies the channel of transmission and uses micro level variation. It thus makes us confident that our estimates capture risk transmission from sovereign to insurers.

Sovereign risk transmission through international activities of insurers

Next, we broaden our view from home sovereign risk transmission to international risk transmission. Column 3 controls for the riskiness of the overall sovereign bond portfolio[28] and column 4 considers domestic and foreign investment separately. The results confirm that international risk transmission takes place and that markets take into account investment risks in an insurer's balance sheet. These connections have so far not been acknowledged in major

[27] At the 75% percentile, home sovereign bonds amount to 10% of total assets, while, at the 25% quantile, they amount to a mere 2% of total assets.

[28] We measure the default risk of an insurer's sovereign bond portfolio through an exposure-weighted average of CDS premiums on sovereign bonds in an institution's portfolio (as explained in Section 3).

insurance regulations, such as Solvency I in Europe. The traditional regulatory view is that risks in insurance are driven by insurance policy-related risks on the liability side and not asset-related risks (Schinasi (2005), p.266). The regulatory treatment of investment risks in Europe will be changed with the introduction of Solvency II in 2016; our results point to the importance of these changes since they underline the fact that sovereign bonds cannot be considered as risk-free. However, sovereign bond holdings denominated in domestic currency will remain largely exempted from capital requirements.

Implicit government guarantees

Home sovereign risk appears to have an effect over and above the risk associated with the portfolio exposure. This can be seen in column 1 of Table 6, as the effect of home sovereign risk on insurers remains significant even after controlling for the effect of the portfolio channel. This baseline effect, however, is similar to the impact of sovereign stress on the non-financial sector. If anything, the remaining effect on insurers is slightly smaller than for non-financial corporations. The point estimates are 0.130 for insurers (see Table 6, column 1) compared with 0.166 for non-financial firms (see Table 5, column 3). This latter estimate is obtained by the sum of the baseline effect of sovereign risk on firm risk (=0.299) plus the non-financial firm-specific effect of sovereign risk (=-0.133) (see Table 5, column 3). The difference between insurers and non-financial firms thus disappears once we control for the large holdings of sovereign debt by insurers. If implicit government guarantees exist for insurers in general, we would have expected home sovereign risk to have a greater impact on insurers than on non-financials, even after controlling for the portfolio channel. For the average insurance company in our sample we thus do not find evidence in line with the existence of implicit government guarantees. Below we will, however, show that the result is different for the systemically important insurers.

Next, we look at differences between insurers. In column 3 we differentiate between insurers that have been classified as systemically important by the Financial Stability Board in July 2013 (FSB, 2013) and those who have not. The decision on the systemic importance of insurers by the FSB is based on five criteria (Size, Global Activity, Interconnectedness, Non-traditional and non-insurance activities, Substitutability; see IAIS (2013)). Note that this decision by the FSB was taken after the end of our sample period. We thus do not test the effect of the announcement. Instead, we analyse whether the CDS spreads of the systemically important insurance companies reacted more sensitively to sovereign risk than others before the FSB decision. Indeed, the elasticity of insurers' risk to sovereign risk is higher for

systemically important insurers by 0.2 percentage points. This is a substantial difference given the baseline effect of around 0.1. This difference between systemic important and other insurers is not driven by differences in the sovereign bond exposure as we simultaneously control for the riskiness of the sovereign bond portfolio.

All in all, after controlling for sovereign bond exposure, insurers – on average – are not more sensitive to sovereign risk than non-financial firms. However, systemically important insurers seem to be more closely linked to their home sovereign than other insurers. This is not a direct test for the existence of implicit guarantees but provides a clue that should be explored further in future research.

4.4 Heterogeneity across countries and over time

Our panel dataset, which covers various countries, allows testing for heterogeneity in the transmission of sovereign risk between countries and over time. The euro area is a special case during our sample period from 2008 until May 2013, since several countries experienced a severe sovereign debt crisis. Hence, in Table 7, we investigate the sovereign risk transmission within the euro area in more detail. Column 1 shows that, compared with other countries, the sensitivity to sovereign risk of insurers located in a euro area country was higher. Next we study whether the level of sovereign risk plays a role in risk transmission to domestic insurers. We do so by including an interaction effect between the log changes of home sovereign risk with the level of home sovereign risk. Results are shown in column 2 and confirm that the elasticity of insurer risk is higher in crisis countries than in relatively safe countries. Thus, the transmission of sovereign risk to insurers is heterogeneous across countries.

Next, we focus on euro area insurers only and investigate changes in the sovereign-insurer relationship over time. Within our sample period, we distinguish the pre-sovereign debt crisis period (2008-2010), the height of the sovereign debt crisis (2010-mid-2012) and the period after the speech of Mario Draghi in London, where he announced that the ECB would do "whatever it takes" to protect the euro within the limits of its mandate, and the subsequent announcement of outright monetary transactions (OMT) (since 26 July 2012 until May 2013) respectively. There is evidence that insurance companies reacted to this speech by Mario Draghi in their asset portfolio allocation (Bijlsma and Vermeulen (2015)). Bijlsma and Vermeulen (2015) find that Dutch insurers showed a marked flight to quality behaviour in their sovereign bond portfolios during the height of the sovereign debt crisis. The flight to quality behaviour disappeared however after ECB chairman Draghi's speech mid-2012.

Column 3 shows that the transmission of home sovereign risk to insurer risk in the Eurozone did not change significantly between these time periods. While the level of sovereign and insurer risk changed over time (see e.g. Figure 1), the transmission effects remained fairly stable.

5 Conclusion

In this paper, we have addressed the following questions: Is domestic sovereign risk transmitted to insurers' default risk? Are insurers affected differently by sovereign risk than other sectors of the economy (i.e. banks and non-financial firms)? Which transmission channels play a role?

We find a strong and highly significant link between sovereign default risk and risks in the insurance sector. Such transmission has been found for a number of different sectors. We document that there are, however, major differences in the extent of vulnerability of the various sectors. Insurers are – depending on the country sample – similarly or less affected by sovereign risk than banks, but always more than non-financial firms. Once the insurers' investments are taken into account, the transmission of risk to the insurance sector is similar to the transmission to non-financial firms.

We investigate why such differences arise and find that the main driver for the strong transmission of sovereign risk to insurers is the large portfolio investments of insurers. This holds true not only for domestic risk transmission but also for transmission of sovereign risk internationally. We document a home bias as well as a high concentration as measured by the Herfindahl-Herschman-Index. Importantly, the concentration (along with the home bias) has increased substantially since the beginning of 2010. Also, heterogeneity between insurers is high, with Italian insurers being particularly exposed to the home sovereign. The incentives behind this home bias may be an interesting avenue for future research.

Looking at differences between insurers, we find that sovereign risk has a greater impact on insurance companies that have afterwards been designated as systemically important by the FSB. This finding indicates that government guarantees might play a bigger role for some insurers.

Finally, we look at heterogeneity across countries and time in greater detail. We find that the risk transmission to insurers is stronger in high-risk countries. Similarly, the link from the sovereign to domestic insurers is stronger in the euro area than in other regions. During our sample period from 2008 to 2013, the transmission of sovereign default risk to domestic insurers' default risk remained fairly stable.

Overall, our results underline the fact that sovereign bonds should not be regarded as a risk-free investment. We provide a detailed analysis of how sovereign risk is transmitted to insurers' default risk and find the asset portfolio channel to be important. Hence, markets generally take sovereign bond portfolio risks into account when assessing insurers' default risk. Seen in that light, our results challenge the regulatory treatment of sovereign bonds in most jurisdictions, including future Solvency II regulations in Europe, which exempts EU sovereign bonds from any capital charge for the calculation of the Solvency Capital Requirement. Future research is needed to better understand investment incentives induced by insurance regulation and their general equilibrium effects.

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Annex

List of life insurers

ACE Ltd
Achmea Hypothekeenbank NV
*Aegon N.V.
*Ageas N.V.
*Allianz AG
Allstate Corp
Aon Corp
*Assicurazioni Generali S p A
*Aviva plc
*AXA
Genworth Financial Inc
Groupe des Assurances Mutuelles Agricoles
*Hannover Ruck AG
*ING Verzekeringen NV
*Legal & Gen Gp PLC
Liberty Mutual Group Inc
MetLife Inc
*Munich Re
Old Mutual plc
Prudential Financial Inc
*Prudential PLC
*Royal & Sun Alliance Insurance Group plc
*SCOR
SNS Bank
Sompo Japan Insurance Inc
*Standard Life Assurance Co
*Swiss Life Insurance & Pension Co
*Swiss Reinsurance Co
*Zurich Insurance Co Ltd

* Information on sovereign bond portfolio available in JP Morgan Cazenove (2014) dataset

Table 1: Summary statistics of variables

Table 1 gives descriptive statistics of the estimation sample (left-hand side) and the full sample (right-hand side) of insurer and country specific variables. Note that variables are not yet transformed into log differences in this table (like in the regressions) in order to facilitate interpretation of magnitudes. Panel a shows the sample of the regressions of insurer risk and performance in Tables 2, 4, 6 and 7. Panel b shows the sample of regressions on risk of insurers, banks and non-financial firms in Table 5. The sample covers the period from January 1st 2008 to May 1st 2013 for panel a and b.

a. Estimations of insurer risk

	Estimation sample			Full sample		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Insurer CDS (bp.)	34683	190.03	248.26	41762	188.72	242.42
Sovereign CDS (bp.)	34683	63.04	57.05	54035	59.62	60.33
Stock index volatility	34683	24.94	10.43	54190	25.41	10.87
Stock index	34683	5067.25	5926.82	55378	4825.47	6530.06
Banking system CDS (bp.)	34683	150.35	67.49	55013	153.61	72.94
Systemically important dummy	34683	0.26	0.44	56347	0.17	0.38
Home sovereign bonds / total assets	10257	0.06	0.05	11840	0.07	0.06
Home sovereign bonds (EUR million)	11593	22966.18	22361.50	13505	25066.43	24117.67

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b. Are insurers different?

	Estimation sample			Full sample		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
CDS (bp.)	502497	222.37	388.53	649271	259.02	4349.82
of which						
Insurer CDS	*34735*	*190.02*	*248.14*	*41762*	*188.72*	*242.42*
Bank CDS	*115539*	*226.21*	*356.52*	*135977*	*222.35*	*364.04*
Non-financial firm CDS	*352223*	*224.30*	*409.24*	*471532*	*275.82*	*5099.85*
Sovereign CDS (bp.)	502497	66.40	68.94	642456	61.18	63.99
Stock index volatility	502497	25.33	10.43	635050	25.84	10.69
Stock index	502497	5345.31	6248.06	633641	4816.03	5933.28
Insurer dummy	502497	0.07		649271	0.06	
Banks dummy	502497	0.23		649271	0.21	
Basic material dummy	502497	0.09		649271	0.09	
Consumer goods dummy	502497	0.15		649271	0.15	
Consumer services dummy	502497	0.19		649271	0.19	
Energy, oil & gas dummy	502497	0.03		649271	0.04	
Health care dummy	502497	0.04		649271	0.04	
Industrials dummy	502497	0.13		649271	0.14	
Technology dummy	502497	0.03		649271	0.03	
Telecom. dummy	502497	0.05		649271	0.05	

Table 2: Baseline regressions explaining change in insurance risk

Table 2 gives regression results for estimating the determinants of insurer risk. The log change of insurer *i*'s CDS spread is the dependent variable. All explanatory variables are measured in log changes. Column 4 includes time fixed effects. The sample covers the period from January 1st 2008 to May 1st 2013. Cluster robust standard errors (clustered at time t) are shown in brackets. ***, **, * = significant at the 1%, 5%, 10% level.

	(1)	(2)	(3)	(4)
Home sovereign CDS	0.185***	0.124***	0.067***	0.018***
	(0.015)	(0.012)	(0.008)	(0.005)
Home stock index volatility		0.062***	0.022**	0.000
		(0.011)	(0.010)	(0.013)
Home stock index		-0.578***	-0.238***	-0.109**
		(0.059)	(0.044)	(0.051)
Home banking system CDS			0.415***	0.139***
			(0.024)	(0.017)
Constant	0.000	0.000	0.000	0.001***
	(0.001)	(0.001)	(0.000)	(0.000)
Observations	34,683	34,683	34,683	34,683
Number of insurers	29	29	29	29
Time FE	N	N	N	Y
R-squared	0.049	0.123	0.231	0.366

Table 3: Baseline regressions with insurer stock price as dependent variable

Table 3 gives regression results for estimating the determinants of insurer performance. The log change of insurer i's stock price is the dependent variable. All explanatory variables are measured in log changes. Column 4 includes time fixed effects. The sample covers the period from January 1st 2008 to May 1st 2013. Cluster robust standard errors (clustered at time t) are shown in brackets. ***, **, * = significant at the 1%, 5%, 10% level.

	(1)	(2)	(3)	(4)
Home sovereign CDS	-0.070***	-0.041***	-0.029***	-0.016***
	(0.009)	(0.007)	(0.007)	(0.005)
Home stock index volatility		-0.207***	-0.189***	-0.133***
		(0.008)	(0.009)	(0.011)
Home banking system CDS			-0.109***	-0.032
			(0.019)	(0.025)
Constant	0.000	-0.000	0.000	-0.009***
	(0.001)	(0.000)	(0.000)	(0.003)
Observations	26,252	26,252	26,252	26,252
Number of insurers	30	30	30	30
Time FE	N	N	N	Y
R-squared	0.104	0.238	0.251	0.468

Table 4: Instrumented variables regressions explaining change in insurance risk

Table 4 gives instrumented variables regression results for estimating the determinants of insurer risk (second stage). The log change of insurer *i*'s CDS spread is the dependent variable. Home sovereign CDS and home banking CDS are both instrumented by average foreign sovereign and banking system CDS. In Column 2 we additionally include the interbank rate as instrument. All explanatory variables are measured in log changes. The sample covers the period from January 1st 2008 to May 1st 2013. Cluster robust standard errors (clustered at time t) are shown in brackets. ***, **, * = significant at the 1%, 5%, 10% level.

	(1)	(2)
Home sovereign CDS	0.126**	0.200***
	(0.051)	(0.070)
Home banking system CDS	0.702***	0.658***
	(0.046)	(0.058)
Stock index volatility	-0.012	-0.012
	(0.010)	(0.010)
Home stock index	0.053	0.061
	(0.048)	(0.048)
Constant	-0.000	-0.000
	(0.000)	(0.000)
Observations	34,597	34,457
Number of insurers	29	29
R-squared	0.181	0.170

Table 5: Are insurers different?

Table 5 gives regression results for estimating sovereign risk transmission to insurers, banks and non-financial firms. The log change of a company *i*'s CDS spread is the dependent variable. All explanatory variables are measured in log changes. Column (1) gives the pooled effect of domestic sovereign risk. In column (2) to (4) the insurance sector is the omitted category and reflected in the baseline effect of sovereign risk. The sample covers the period from January 1st 2008 to May 1st 2013. Column (3) is estimated on a restricted sample including only European firms and the time period October 1st 2009 to March 31st 2013 in order to have a comparable sample to Table 6. Column (4) gives a detailed breakdown in non-financial sectors and is based on the full sample. Column 5 includes day fixed effects. Cluster robust standard errors (clustered at time t) are shown in brackets. ***, **, * = significant at the 1%, 5%, 10% level.

	(1)	(2)	(3)	(4)	(5)
	Aggregate view	Sectoral breakdown	European sample	Disaggregate breakdown	Disaggregate breakdown
Home sovereign CDS	0.082***	0.130***	0.299***	0.130***	0.049***
	(0.008)	(0.012)	(0.027)	(0.012)	(0.007)
Home stock index volatility	0.054***	0.054***	0.026**	0.054***	0.015**
	(0.007)	(0.007)	(0.010)	(0.007)	(0.007)
Home stock index	-0.540***	-0.535***	-0.478***	-0.534***	-0.213***
	(0.039)	(0.038)	(0.045)	(0.038)	(0.027)
Banks *home sov CDS		0.012	0.029**	0.012	0.014*
		(0.009)	(0.012)	(0.009)	(0.008)
Real sector *home sov CDS		-0.065***	-0.133***		
		(0.008)	(0.015)		
Basic materials *home sov CDS				-0.050***	-0.044***
				(0.008)	(0.008)
Consumer goods *home sov CDS				-0.062***	-0.055***
				(0.009)	(0.008)
Consumer services *home sov CDS				-0.074***	-0.058***
				(0.009)	(0.008)
Energy, oil & gas *home sov CDS				-0.082***	-0.055***
				(0.009)	(0.008)
Health care *home sov CDS				-0.091***	-0.058***
				(0.010)	(0.008)
Industrials *home sov CDS				-0.047***	-0.044***
				(0.008)	(0.008)
Technology *home sov CDS				-0.085***	-0.062***
				(0.010)	(0.009)
Telecom. *home sov CDS				-0.053***	-0.043***
				(0.008)	(0.008)
Constant	0.000	0.000	0.001	0.000	-0.017
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Observations	465,285	465,285	202,664	465,285	465,285
Time FE	N	N	N	N	Y
Number of firms	379	379	253	379	379
R-squared	0.121	0.124	0.207	0.124	0.284

Table 6: Regressions explaining transmission channels

Table 6 gives regression results for estimating the transmission channels from sovereign risk to insurer risk. The log change of insurer i's CDS spread is the dependent variable. All explanatory variables are measured in log changes. The exposure and portfolios variables are measured as shares relative to total assets and are drawn from JPMorgan publications. An insurer is SIFI if it has been classified as systemically important by the FSB. The sample covers the period from October 1st 2009 to May 1st 2013 and 17 large European insurers. In column (2) country-time fixed effects are introduced and absorb the baseline sovereign risk effect. Cluster robust standard errors (clustered at time t) are shown in brackets. ***, **, * = significant at the 1%, 5%, 10% level.

	(1)	(2)	(3)	(4)	(5)
	Home Portfolio Channel	Country-Time FE	Overall Sovereign Portfolio	Home and Foreign Sovereign Portfolio	Systemic Relevance
Home sovereign CDS	0.130***		0.114***	0.120***	0.052**
	(0.023)		(0.021)	(0.022)	(0.021)
Stock index volatility	0.007		0.006	0.005	0.012
	(0.012)		(0.012)	(0.013)	(0.012)
Home stock index	-0.343***		-0.323***	-0.325***	-0.318***
	(0.045)		(0.045)	(0.045)	(0.044)
Home banking system CDS	0.375***		0.367***	0.367***	0.356***
	(0.035)		(0.034)	(0.034)	(0.033)
Exposure to home sovereign * CDS	0.763***	0.957**		0.417**	0.367*
	(0.194)	(0.455)		(0.203)	(0.204)
Riskiness of overall sovereign portfolio			0.542***		
			(0.096)		
Riskiness of foreign sovereign portfolio				0.568***	0.533***
				(0.126)	(0.123)
SIFI insurer * home sovereign CDS					0.188***
					(0.018)
Constant	0.000	0.001***	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	10,256	10,256	10,256	10,256	10,256
Number of insurers	15	15	15	15	15
R-squared	0.416	0.855	0.422	0.422	0.431

Table 7: Heterogeneity across countries and over time

Table 7 gives regression results for estimating the transmission channels from sovereign risk to insurer risk across countries and time. The log change of insurer i's CDS spread is the dependent variable. All explanatory variables are measured in log changes. The period "Prior to debt crisis" runs from January 1st 2008 to January 1st 2010. The period "Height of sovereign debt crisis" is defined from January 1st 2010 until the speech by Draghi at July 26 2012, when Draghi first announced the OMT and that the ECB would "do whatever it takes" ("post Draghi speech"). Cluster robust standard errors (clustered at time t) are shown in brackets. ***, **, * = significant at the 1%, 5%, 10% level.

	(1) All countries Eurozone Effects	(2) All countries Country Risk effects	(3) Eurozone Time period split
Home sovereign CDS	0.036***	0.049***	0.164***
	(0.007)	(0.010)	(0.023)
Stock index volatility	0.027***	0.023**	0.019
	(0.010)	(0.010)	(0.014)
Home stock index	-0.192***	-0.224***	-0.227***
	(0.044)	(0.045)	(0.050)
Home banking system CDS	0.407***	0.412***	0.478***
	(0.023)	(0.024)	(0.045)
Home sovereign CDS*Euro Area	0.163***		
	(0.020)		
Home sovereign CDS*Level of sovereign CDS		0.041***	
		(0.014)	
Home sovereign CDS * Height of sovereign debt crisis			-0.028
			(0.041)
Home sovereign CDS * Post Draghi speech			-0.011
			(0.034)
Height of sovereign debt crisis			0.001
			(0.001)
Post Draghi speech			-0.000
			(0.001)
Constant	0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)
Observations	34,683	34,683	11,601
Number of insurers	29	29	9
R-squared	0.237	0.231	0.285