NAIC NATIONAL ASSOCIATION OF INSURANCE COMMISSIONERS

Volume 43, Number 1
DOI: 10.52227/26725.2024

The Journal of Insuranc s to make state insurance departments more aware of the c research occurring in the regulatory arena. All authors havi insurance regulation are invited to submit manuscripts t . Before appearing in the Journal, each article is rigorously itorial Review Board to ensure that all information provide aders and is of the utmost quality. The ideas expressed in th sed by the NAIC, CIPR, the Journal's editorial staff, or the

ssociation of Insurance Commissioners

A C í
I í

Fabian Regele
Helmut Gründl

Historical evidence, such as the global financial crisis of 2007–2009, shows that sectoral asset concentrations can play an important role in insurers' solvency. However, current regulatory frameworks, such as the U.S. risk-based capital (RBC) and the European Union (EU) Solvency II, neglect sectoral asset concentrations when determining capital requirements, potentially underestimating the systematic loss exposure of asset portfolios and reducing incentives to mitigate the corresponding risk.

To assess the solvency risk associated with sectoral asset concentrations, we conduct an empirical analysis based on the statutory filings of 2,708 U.S. insurers over the period from 2009 to 2018. By creating a detailed dataset of their asset holdings, we find that insurers are particularly concentrated in the financial, public, and real estate sectors but also engage in significant asset reallocations, particularly in terms of a declining trend in public sector investments.

To study the potential impact of sectoral asset concentrations on insurers' solvency, we conduct a regression analysis. We use the Z-score to measure solvency and the Herfindahl-Hirschman Index (HHI) to measure insurers' sectoral asset concentration. We find that sectoral asset concentrations can be both beneficial and detrimental to insurers' solvency, depending on the specific sector in which asset portfolios are concentrated. In particular, while asset concentrations in the public sector significantly improve insurers' solvency, asset concentrations in the real estate sector significantly weaken it. One source of concentration risk in the real estate sector can be seen in the existence of speculative, periodically bursting bubbles, one of which triggered the subprime mortgage crisis of 2007–2009.

Our findings can serve as a starting point for revising current regulatory practices regarding risk-adequate capital requirements but also for creating proactive incentives for insurers to mitigate the accumulation of systematic risk associated with sectoral asset concentrations. To foster market discipline, a first step could be to increase public disclosure requirements for insurers regarding their sectoral asset concentrations.

Both authors are affiliated with the International Center for Insurance Regulation (ICIR), Goethe-University Frankfurt, Theodor-W.-Adorno Platz 3, D-60629 Frankfurt am Main, Germany. E-mail: regele@finance.uni-frankfurt.de. Fabian Regele gratefully acknowledges research funding from the SAFE Research Center, funded by the State of Hesse initiative for research LOEWE.

A C í
I í

Fabian Regele
Helmut Gründl

AB AC

Historical evidence, like the global financial crisis from 2007–2009, highlights that sectoral asset concentrations can play an important role in the solvency of insurers. Yet, current regulatory frameworks, such as the U.S. risk-based capital (RBC) framework, neglect sectoral asset concentrations in the determination of capital requirements, potentially underestimating the asset portfolio's systematic loss exposure and reducing incentives for corresponding risk mitigation. By creating a detailed data sample of U.S. insurers' asset holdings from 2009 to 2018 by means of their statutory filings, we find that insurers concentrate their assets particularly toward the financial, public, and real estate sector and that sectoral asset concentrations toward the public sector are associated with improved solvency, while concentrations toward the real estate sector weaken solvency. Our findings can serve as a starting point to revise current regulatory practices, particularly in terms of creating proactive incentives for insurers to mitigate the accumulation of systematic risk exposures associated with sectoral asset concentrations.

Keywords: Insurance regulation, sectoral asset concentration risk
JEL Classification: G01, G11, G22, G28

Both authors are affiliated with the International Center for Insurance Regulation (ICIR), Goethe-University Frankfurt, Theodor-W.-Adorno Platz 3, D-60629 Frankfurt am Main, Germany. E-mail: regele@finance.uni-frankfurt.de. Fabian Regele gratefully acknowledges research funding from the SAFE Research Center, funded by the State of Hesse initiative for research LOEWE.

.I í

Insurers invest enormous amounts of premium income, reserves, and equity capital on the capital markets.[1] A concentration of assets in terms of business sectors can generally lead to material loss exposures for financial institutions, as the asset portfolio is increasingly subject to systematic risk exposures. The global financial crisis from 2007 to 2009 provides a prominent example for the financial impact of sectoral asset concentrations on the solvency of insurers. In 2007, AIG and MetLife concentrated 24% and 21%, respectively, of their total assets in the real estate sector, contributing to the material losses for both insurers when the U.S. real estate sector systematically collapsed due to changes in interest rates (McDonald and Paulson, 2015).

Current regulatory frameworks, such as the U.S. risk-based capital (RBC) framework and Solvency II for the European Union (EU), neglect the concentration of assets toward business sectors in the determination of capital requirements for asset concentration risk. In that regard, the capital requirements can underestimate the asset portfolio's systematic loss exposure arising from material and sudden changes in the macroeconomic condition for the invested firms. In the case of a systematic macroeconomic shock, such as changes in interest rates or oil prices, systematic losses materialize that are difficult to manage, and insurers might have insufficient levels of capital to withstand the shocks. Due to the exclusion of the sectoral concen-

and health insurers, as well as reinsurers. Third, we address the prudential aspects linked to sectoral asset concentrations.

To shed light on these issues, we conduct an empirical assessment based on U.S. insurers' statutory filings over the time period of 2009 to 2018. The analysis aims to provide evidence on how insurers invest their assets regarding sectors, and how

hold for other frameworks as well, such as Solvency II for the EU, which also neglects sectoral asset concentrations in the determination of capital requirements.

Sectoral asset concentrations as a particular dimension of the investment behavior of financial institutions have been studied mainly in banking literature but not in insurance literature. Findings by Beck et al. (2022), Grippa and Gornicka (2016), Düllmann and Masschelein (2007), and Gordy (2003) show that the sectoral concentration in banks' assets can have a substantial impact on their solvency. Regarding property-liability insurers' investment activities, Che et al. (2021) investigate the hedging motive and sector expertise as drivers for sector underweighting and overweighting. The regulatory implications of the investment behavior of insurers have been studied from multiple different perspectives outside the concentration risk angle, for instance, regarding fire sales (e.g. Ellul et al., 2011), reaching for yield behavior (e.g. Becker and Ivashina, 2015) or procyclicality (e.g. Bijlsma and Vermeulen, 2016; Bank of England [BoE], 2014). Evidence on the loss potential associated with sectoral asset concentrations and subsequent regulatory implications are therefore a research gap in the insurance literature. Particularly the lack of publicly available, sufficiently granular investment data of high quality is a major hindering factor to assess whether insurance regulation needs to be revised regarding asset concentration risks (IAIS, 2018b). By analyzing the dynamics of sectoral asset concentrations and their impact on insurers' financial health, we offer a complementary perspective on the complexities of the investment behavior of insurers and the corresponding regulatory treatment.

Our findings also contribute to the literature and discussions around macroprudential insurance regulation, in which sectoral asset concentrations are discussed as a potential source for systemic risk (European Systemic Risk Board [ESRB], 2020; European Insurance and Occupational Pensions Authority [EIOPA], 2019b; International Association of Insurance Supervisors [IAIS], 2018a). In that regard, it is important that microprudential and macroprudential insurance regulation treat sectoral asset concentrations consistently, as a potential misalignment in the approaches could lead to unintended, financial(o)9npdtudt sectoral6 Tm[(t 0.04Twa)0.1was5s5(s0hr Tm[(and spdtctuand t

funds) and collect the data from S&P Global Market Intelligence. Since the statutory filings contain the CUSIP numbers of the invested assets, but do not comprise specific information about their corresponding business sectors, we conduct an asset-to-asset CUSIP matching with multiple databases (Bloomberg, Refinitiv Eikon, CRSP, and MSRB) to obtain sectoral classifications of the reported assets. For the CUSIP-based sectoral asset classifications, we use the GICS as the main sectoral classification system. If a GICS classification is not available for a given asset, we aim to get the Thomson Reuters Economic Sector variable. The public administration sector is originally not part of the GICS system, but we treat it as a separate sector to comprise the typically large investments of insurers in public debt instruments and to get an economic perspective of the corresponding effects on the insurers' solvency.

Regarding an asset's value as the main determinant for a portfolio's sectoral concentration, we follow the NAIC in its market analyses and use the reported book/adjusted carrying value (BACV) of the asset. The BACV is an accounting-based measure that considers the asset's book value adjusted by the insurer for certain economic factors (e.g., market developments) to reflect the asset's actual economic value. The BACV is the essential determinant to calculate the insurers' asset-related capital requirements in the U.S. RBC framework.

We measure the insurers' sectoral asset concentration by means of the HHI. The HHI as a concentration measure has been frequently used in the literature, for instance by Shim (2017a, 2017b) and Acharya et al. (2006). The insurers' sectoral HHI per year is determined by the sum of the squared ratios of the aggregated asset values in terms of the BACV allocated to a specific sector to the portfolio's total value of assets. Thereby, a higher HHI value indicates the asset portfolio to be stronger concentrated, whereas a lower HHI value indicates the asset portfolio to be more diversified, i.e., less concentrated. The insurer sample for the analysis consists of 2,708 individual U.S. entities registered by a company code with the NAIC over the time period from

types. Insurers' large investments in mortgage loans comprise 72% of the sectoral investments related to real estate, followed by bonds issued by firms in the real estate sector (18%). Insurers' direct property holdings amount to 4% of the investments in the real estate sector, and the long-term assets, based on a look-through approach by means of the assets' reported CUSIP and line numbers, amount to 5%. Comparing the recent allocations in 2018 with the long-term average values over 2009–2018, we see only limited changes per asset type for most sectors, except for the real estate sector, which shows a material shift from bond-related investments (18% in 2018, 62% long-term average) to mortgage loans (72% in 2018, 25% long-term average) over time.

: Invested Asset Types in 2018

Sector	Allocation	Bonds	Stocks	Long-Term	Direct Property	Mortgage Loans
Financials	0.33	0.73	0.24	0.03	-	-
	(0.32)	(0.78)	(0.21)	(0.01)		
Real Estate	0.13	0.18	0.01	0.05	0.04	0.72
	(0.07)	(0.62)	(0.01)	(0.06)	(0.06)	(0.25)
Public Admin.	0.10	1.00	-	-	-	-
	(0.13)	(1.00)				
Industrials	0.06	0.75	0.11	0.14	-	-
	(0.06)	(0.78)	(0.10)	(0.12)		
Utilities	0.05	0.98	0.02	-	-	-
	(0.05)	(0.98)	(0.02)			

Table 2 shows the asset types of the insurers' investments in the five most important sectors in 2018. In parentheses are the long-term average values for the period 2009 to 2018. *Own Table*.

3:

Several insurer-specific control variables (CVs) are employed in the model. The sectoral HHI is an aggregated measure and is informative of the overall impact of sectoral asset concentrations on insurers' solvency. Since economic sectors typically show systematic differences in their financial performance influencing insurers' solvency, and individual insurers might overweight or underweight their asset allocations to specific sectors for strategic reasons, e.g., due to informational advantages as suggested by Che et al. (2021), we assess by means of indicator variables to which of the invested sectors the asset portfolio was concentrated in the given year (maximum of the percentage of sector-specific assets to total assets). We control for the insurers' size since larger institutions tend to be more financially stable because their larger asset and underwriting risk pools benefit more from risk diversification effects (Shim 2017b; Liebenberg and Sommer, 2008). However, large insurers may also be incentivized to engage in excessive risk taking, as they may be considered "too big to fail," which could reduce their solvency (Financial Stability Oversight Council [FSOC], 2013). We further control for the asset risk in the insurers' portfolios to the fraction of fixed-income assets since a higher seniority of assets raises the portfolios' resilience against financial shocks (Shim 2017b). As the leverage of a financial institution can influence its potential to withstand financial shocks and thereby influence its solvency, we control for the insurers' leverage (Shim, 2017b; Chen and Wong, 2004; Carson and Hoyt, 1995). Moreover, as insurers also engage in non-insurance related activities, such as securities lending or derivatives trading that can affect their solvency (e.g., IAIS, 2019), we control for the engagement in non-insurance related activities (Bierth et al., 2015; Weiß and Mühlnickel, 2014). We also control for the level of underwriting risk since particuce ii0.5y5(c)0 uagement5(c)0 enemenxagemen5(c)0(f)3Te5(c)0 uagement5(c)0d3Te5(c)0ii0.

asset allocation as an explanatory variable, we lag all explanatory variables by one year. An overview of the variables is provided in Appendix A.4 (Table 12).

The sample of insurers is based on U.S. entities registered by a company code with the NAIC. To mitigate selection and survivorship bias, the sample includes operating and non-operating insurers. The sectoral asset concentrations, as described in Section 3.1, are based on reported asset data regarding the investment schedules A (real estate), B (mortgage loans on real estate), D (bonds, preferred and common stocks),

bond investors. On average, around 80% of the investments are made through bonds. Leverage, linked to the financial buffer of insurers to withstand potential shocks, is at a moderate level on average. Moreover, the average insurer engages only moderately in non-insurance activities, with an average ratio of total liabilities to policyholder surplus of 2.8. The distribution of the variables underwriting risk, reinsurance, and age shows material cross-sectional variation among insurers and is in line with the literature (Che et al., 2021).

: Descriptive Statistics of the Sample

Variable	Mean	SD	Min	Max

: Baseline Regression Results

	Dependent Variable	
	Z-score	Z-score (TS)
HHI	0.484***	0.311***
	p = 0.000	p = 0.000
Size	0.057***	0.042***
	p = 0.000	p = 0.000
Asset Risk	0.381***	0.241***
	p = 0.000	p = 0.000
Leverage	- 0.170***	- 0.150***
	p = 0.000	p = 0.000
Non-Insurance Activities	- 0.041***	- 0.046***
	p = 0.000	p = 0.000
Underwriting Risk	- 0.156***	- 0.117***
	p = 0.000	p = 0.000
Reinsurance	0.001	0.071
	p = 0.990	p = 0.156
Age	0.113***	0.131***
	p = 0.000	p = 0.000
Group	0.085**	0.043
	p = 0.030	p = 0.250
Ownership	- 0.070*	- 0.120***
	p = 0.090	p = 0.002
Year Fixed Effects	Y	Y
Firm Clustered SE	Y	Y
Observations	21,038	20,949
R2	0.113	0.173
Adj. R2	0.113	0.173

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5 shows the results of the OLS panel regression on the model given by Equation (2) from 2009 to 2018. Definitions of the variables are provided in Appendix A.4. Explanatory variables are lagged by one year, and the dependent variables, the size variable, and the age variable are in logarithmic terms. All panel regressions are estimated with year-fixed effects and clustered standard errors at the insurer level. Model (1) refers to the Z-score estimated by means of a three-year rolling window over the RoA observations, and Model (2) refers to the Z-score estimated by means of the insurers' entire time series of RoA observations. *Own Table*.

Given the expectation that a higher sectoral asset concentration typically leads to higher systematic risk exposures in the portfolio, the finding of a positive relationship indicating improvements in the insurers' solvency is surprising. It can be explained by the insurers' typical investment behavior and the fact that the HHI is an aggregated concentration measure that does not depict the interaction of the sectoral asset allocations influencing the volatility of the asset portfolio's overall returns. Insurers tend to concentrate their assets in the public sector, which is considered to provide relatively safe asset returns in terms of the high-quality sovereign bonds in which insurers usually invest. A higher sectoral HHI is, therefore, largely associated with an increase in the asset allocation toward the public sector. Due to the low systematic risk

exposure of assets related to the public sector, the asset portfolio's total systematic risk exposure reduces, which improves the solvency of an insurer. Moreover, a similar rationale holds for the insurers' asset allocations to the utilities sector, which is usually providing stable asset returns due to its stable economic activity of providing electric, gas, or water services essential for the real economy and society. Also, given that insurance-related assets are typically less risky than banking-related assets, an increase in the sectoral asset concentration toward the financial sector can also improve the asset portfolio's overall risk exposure. The positive relationship between the sectoral asset concentration and the insurers' solvency suggested by the regression analysis is further supported by findings in the literature, as Beck et al. (2022) find a positive impact of a bank's sectoral asset concentration on a bank's default risk, consistent with the financially stabilizing benefits stemming from better risk management of concentrated asset portfolios due to informational advantages or risk monitoring (Acharya et al., 2006).

The baseline regression findings suggest that from an aggregated perspective in terms of the sectoral HHI measure, higher levels of sectoral asset concentrations can be positive for the solvency of an insurer. However, since there are typically cross-sectional differences in the financial performance of sectors, and individual insurers might overweight or underweight their investments to specific sectors for strategic reasons (e.g., informational advantages as suggested by Che et al., 2021), we run a complementary regression analysis to focus on the specific sectors to which insurers concentrate their asset portfolios. In this regard, insurers in the sample overall show a maximum allocation of their assets to the financial, public administration, industrials, real estate, energy, consumer staples, and materials sectors. We add an indicator variable to the regression model, indicating in which of these sectors the asset portfolio is concentrated in the given year.

Table 6 provides the results of the baseline regression analysis with an indication on which sector the asset portfolio is concentrated. Asset portfolios concentrated in the public sector are, on average, associated with a higher solvency of the insurer (= 0.104 and = 0.144), which is in line with the typically relatively safe asset returns related to government bonds. Interestingly, the sectoral asset concentration toward the real estate sector is strongly negatively affecting insurers' solvency (= - 0.355 and = - 0.278). The result becomes plausible when considering the recent empirical findings of Fabozzi et al. (2020), who provide evidence for the existence of speculative, periodically bursting bubbles in the real estate sector. Their sample period for the U.S. market is from 1997-2015, which covers most years of our sample period 2009-2018. Our sample period includes years of undervaluation (2009-2014) and years of overvaluation (2015-2018) in the real estate sector (UBS, 2023, p. 9). Thus, we see a persistent bubble risk also after the global financial crisis from 2007-2009, which was associated with substantial losses for financial institutions that had material asset concentrations in the real estate sector (McDonald and Paulson, 2015).

Sectoral asset concentrations toward the financial, energy, and consumer staples sectors tend to improve insurers' solvency, since the Z-score estimated on the full time series of the RoA data (Model 2) shows a weakly significant positive effect. This effect is not evident for a Z-score estimated by means of a three-year rolling window over

the RoA (Model 1). The other control variables in the regression analysis suggest that insurers' size is, on average, associated with a positive and statistically significant impact on their solvency, suggesting larger insurers tend to show better solvency levels. The asset risk variable measuring the fraction of bond investments to total investments shows a positive effect on insurers' solvency, in line with the expectation that bonds

Concentration: Public Admin.	0.104*	0.144***
	p = 0.059	p = 0.005
Concentration: Industrials	- 0.135	- 0.138
	p = 0.683	p = 0.681
Concentration: Real Estate	- 0.355***	- 0.278***
	p = 0.001	p = 0.001
Concentration: Energy	0.229	0.513*
	p = 0.421	p = 0.068
Concentration: Consumer Staples	0.247	0.190*
	p = 0.110	p = 0.084
Year Fixed Effects	Y	Y
Firm Clustered SE	Y	Y
Observations	21,038	20,949
R2	0.116	0.178
Adj. R2	0.115	0.177

Note: *p<0.1; **p<0.05; ***p<0.01

Table 6 shows the results of the OLS panel regression on the model given by Equation (2) from 2009 to 2018. Definitions of the variables are provided in Appendix A.4. Explanatory variables are lagged by one ye (l)0.5a)0.5e)0.5thidhaepery variable ic Adminc .004T

toward the public sector. Consistent with the baseline findings, asset concentrations toward the real estate sector show a negative impact on insurers' solvency.

Secondly, we test for differences in the effect of the sectoral asset concentrations on insurers' solvency per asset type. To maintain the interdependency of the invested asset types in relation to the insurers' solvency, we include indicator variables on whether the asset concentration is related to the investments in bonds, stocks, direct real estate, mortgage loans, and long-term assets. Table 14 (Appendix A.5) underlines the findings of the baseline model regarding the effects of sectoral asset concentrations and shows that investments in stocks and real estate influence insurers' solvency negatively. Long-term assets, which cover particularly private equity and hedge fund investments, also show a negative association with insurers' solvency, whereas investments concentrated in bonds are associated with a positive impact on solvency.

Thirdly, to study if sectoral asset concentrations show a different impact between P/C insurers and L&H insurers, we split the sample accordingly. The findings in Tables 15 (P/C) and 16 (L&H) in Appendix A.5 underline the findings of the main model, i.e., sectoral asset concentrations in general are positively associated with insurers' solvency and that asset concentrations toward the real estate sector reduce the solvency levels, on average. Interestingly, while underwriting risk is negatively associated with the insurers' solvency in both sub-samples, the use of reinsurance is positively associated only with the sub-sample of P/C insurers and negatively associated with the sub-sample of L&H insurers. The existence of negative effects related to the use of reinsurance appears plausible. As Lei (2019) shows, the effect of reinsurance on insurers' financial performance can be considered as a cost-benefit trade-off. The cost of reinsurance can be overall detrimental to the solvency of L&H insurers, as the benefits of L&H

is compared between asset portfolios with varying sectoral asset concentrations and a benchmark portfolio. The benchmark portfolio represents a well-diversified asset portfolio regarding sectoral asset concentrations, with the objective to ensure a specific VaR of the portfolio's asset returns. Comparing the VaR of the insurers' real-world asset portfolio with the VaR of the benchmark portfolio can be the basis for supplementary sectoral capital charges.[13] In particular, given the results of our regression analysis, a regulatory benchmark for asset concentrations in the real estate sector should be established

.C í

This study sheds light on the link between sectoral asset concentrations and insurers' solvency and develops implications for insurance regulation. By analyzing the dynamics of sectoral asset concentrations and their impact on insurers' financial health, we offer a complementary perspective on the complexities of the investment behavior of insurers and the corresponding regulatory treatment, compared to previous studies.

By creating a detailed dataset of U.S. insurers' asset holdings from 2009 to 2018 by means of their statutory filings, we identify material asset concentrations toward sectors such as finance, real estate, and the public sector, and we find that sectoral asset concentrations can be both beneficial and detrimental to the i.5io)0cy8s e5n[(f)0.5o)5(i.5sur)5(

A i A

A, A C `

As to Solvency II, we focus our discussion on its Standard Formula, as it is implemented by most insurers in the European Union (EU) (European Insurance and Occupational Pensions Authority [EIOPA], 2018c; Commission Delegated Regulation [EU] 2015/35). Asset concentration risk is covered in an explicit sub-module within the market risk module, and the corresponding capital charges aim to mitigate idiosyncratic risk exposures stemming from name concentration risk (EIOPA, 2014). A concentration risk capital charge is required if an insurer's aggregated investment in a single name exceeds a predetermined threshold in a range of 1.5% to 15% of the insurer's total assets, depending on the credit rating of the asset. The capital requirements by this sub-module are applicable to several financial instruments, comprising bonds, loans other than residential mortgage loans, equity, and property investments. Government bonds issued by member states of the European Economic Area (EEA) in their domestic currency are exempted from concentration risk charges (Commission Delegated

The aggregation of capital requirements over all different names leads to the asset portfolio's total capital requirement in the asset concentration risk sub-module. However, the aggregation assumes no correlation between these different names in the portfolio and neglects the assets' sector-specific linkages due to common risk exposures, i.e., the assets' systematic risk exposures, which can lead to biased solvency capital requirements.

Like the U.S. risk-based capital (RBC) framework, Solvency II reflects only name concentration risk in the solvency capital requirements for asset concentration risk. However, the corresponding capital requirements differ substantially in their calculation, although both frameworks consider name concentration risk similarly as the risk of an accumulation of idiosyncratic risk exposures compared to a well-diversified asset portfolio. While Solvency II focuses on the asset portfolio's idiosyncratic risk exposure to each name (counterparty) in the portfolio, the U.S. RBC framework considers only the 10 largest names in the portfolio.

A. A C

Table 9 highlights the sectoral asset allocations to the five most important sectors for EU insurers in 2018.

: Overview of the Five Most Important Sectors for EU Insurers in 2018

NACE Sector	Min (%)	Max (%)	Mean (%)
K - Financial and Insurance Activities	17.6% (Croatia)	70.6% (Germany)	42.4%
K64 - Financial Services	8.6% (Croatia)	56.6% (Iceland)	30.4%
O - Public Sector	2.4% (Iceland)	67.2% (Hungary)	35.2%
C - Manufacturing	0.3% (Hungary)	11.2% (Finland)	3.9%
L - Real Estate	0.2% (Poland)	12.0% (Norway)	2.9%
D - Electricity and Gas	0.1% (Hungary)	5.8% (Iceland)	1.9%

Table 9 shows the minimum, maximum, and mean ratio at the country-level of insurers' sectoral asset allocations in 2018. Data is based on Nomenclature of Economic Activities (NACE) classification and provided by European Insurance and Occupational Pensions Authority (EIOPA) (2019a). K64 is a subsector of the financial sector K and mainly comprises banking-like activities.

A. A C . . 'A

We collect insurers' statutory filings with the NAIC from 2009 to 2018 from S&P Global Market Intelligence. Our analysis is based on raw data as reported by life, health, and property/casualty (P/C) insurers to the NAIC with regard to investment schedules A (part 1: direct property), B (part 1: mortgage loans on real estate), D (part 1: bonds; part 2, section 1: preferred stocks; part 2, section 2: common stocks) and BA (part 1: other long-term invested assets, especially private equity funds, hedge funds). The data does not contain assets held by insurers on separate accounts.

The raw dataset provides the assets' Committee on Uniform Security Identification Procedures (CUSIP) numbers and book/adjusted carrying values (BACV). We match the assets' CUSIP numbers with sector classification variables stemming from several other data sources: Bloomberg, Refinitiv Eikon, Center for Research in Security

Prices (CRSP), and Municipal Securities Rulemaking Board (MSRB). For the sector classifications, we use the Global Industry Classification Standard (GICS) as the main sectoral classification system. If a GICS classification is not available for a given asset, we aim to get the Thomson Reuters Economic Sector variable. Public Administration is originally not included in the GICS system, but we add it as an additional sector to comprise the typically large public debt investments of insurers.

For assets we cannot match with a sector classification variable, we use the line numbers that are reported with the assets and match them with the GICS classification system if possible. We classify schedule A and B investments as real estate sector investments in line with McDonald and Paulson (2015) to get an economic perspective on the insurers' risk exposures. For fund investments, we employ a "look-through" approach and classify these investments to a specific sector only if we are able to get information on the funds' actual investments. If we have no clear information for a fund investment, we denote it as unclassified in the sample. We exclude investments with a negative BACV. We also exclude investments that are described as housing tax credits since it is unclear which sectoral risk exposure is most appropriate to describe the

Utilities	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Health Care	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
Consumer Staples	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Energy	0.03	0.04	0.04	0.05	0.05	0.05	0.04	0.04	0.04	0.03
Information Technology	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01
Consumer Discretionary	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.01
Materials	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02
Communication Services	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Residual Sectors (each)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Unclassified Assets	0.12	0.14	0.16	0.16	0.16	0.17	0.18	0.19	0.20	0.20

Table 11, as extension to Table 1, shows the sectoral asset concentrations of the entire sample of 2,708 U.S. insurers from 2009 to 2018, as determined by the book/adjusted carrying value (BACV) of all sector-specific assets aggregated by all insurers in the sample divided by the aggregated BACV of all reported assets. Investment data comprises schedules A, B, D, and BA from the insurers' statutory filings with the NAIC. We follow McDonald and Paulson (2015) and include investments

Asset Risk	Ratio of bond-related investments to total assets. Insurers tend to be conservative investors regarding the seniority of the assets they invest in. Typically, large fractions of the insurers' asset portfolio consist of fixed-income bond investments (Section 3.2). Compared with stock investments, bonds are typically less risky as they provide the investor with a higher claim on the issuing firm's assets in case of a bankruptcy. Therefore, we measure the portfolio's asset risk as the ratio of bond-related investments to total assets. In this regard, a higher ratio of bonds in the asset portfolio of an insurer indicates a safer asset portfolio in terms of a lower exposure against financial shocks, potentially harming the insurers' solvency. In this regard, Shim (2017b) finds a positive influence of the ratio of bond investments to total investments on the insurers' solvency.
Leverage	Ratio of total net premiums earned to policyholder surplus. Insurers typically finance their assets by policyholder premiums, i.e., their underwriting business and not by issuing debt obligations. Therefore, in contrast to banks, which finance uncertain asset returns mainly by certain debt obligations under potentially material duration mismatches, the insurers' leverage needs to be determined differently as for banks. We follow Shim (2017b) and estimate the insurers' leverage as the ratio of total net premiums earned to policyholder surplus. The surplus is an equity position determined by the difference between assets and liabilities, reflecting the financial resilience of an insurer to a shock. A higher leverage due to a lower underwriting-related policyholder surplus can harm the insurers' solvency, for instance in case of an underwriting shock leading to material increases in insurance reserves. Shim (2017b), Chen and Wong (2004), and Carson and Hoyt (1995) show that higher leverage ratios can reduce the solvency of insurers.
Non-Insurance Activities	Ratio of total liabilities to policy holder surplus. Insurers also engage in non-insurance related activities like securities lending or derivatives trading that can affect the insurers' solvency (e.g., International Association of Insurance Supervisors [IAIS], 2019). For instance, losses from securities lending activities have been a major source for AIG's near-collapse during the global financial crisis from 2007 to 2009 (McDonald and Paulson, 2015). Therefore, we follow Bierth et al. (2015) and Weiß and Mühlnickel (2014) and control for non-insurance-related activities by means of determining the ratio of total liabilities to policyholder surplus.
Concentration: Sector	Variables with the prefix "Concentration" are indicators equal to 1 if an insurer has the maximum of its assets (percentage of sector-specific assets to total assets) in the given year concentrated in the respective sector.
Underwriting Risk	Based on Che et al. (2021), we measure underwriting risk by the rolling standard deviation of the underwriting loss ratio (losses incurred and loss adjustment expenses to premiums earned) over the previous three years, and winsorize it at the 99th percentile to reduce the impact of outliers. Higher underwriting risk, particularly in terms of unexpected losses not properly reflected in the pricing of insurance premiums, can be negatively associated with the financial performance of insurers.
Reinsurance	Following Che et al. (2021), the variable is defined as the reinsurance ratio, which is determined as the ratio of premiums ceded to premiums written. Reinsurance is a typical risk mitigation tool of insurers, particularly to protect the ceding company against unexpected underwriting losses. A higher reinsurance ratio could therefore be beneficial to the financial performance of an insurer.

Age	Natural logarithm of age. In relation to Che et al. (2021), the variable is determined as the difference between the year of the observation and the entity's year established. A higher age of the insurer could be associated with higher levels of investment experience as regards specific sectors, i.e., sector-specific information advantages that might lead to abnormal investment returns.
Group	Indicator variable, equal to 1 if the entity is part of a group, and 0 otherwise, to account for systematic differences in the corporate structure of the insurers (e.g., Che et al., 2021; Leverty and Grace, 2018; Shim, 2017a; 2017b).
Ownership	Indicator variable, equal to 1 if the entity is a stock insurer, and 0 if it is a mutual insurer, to account for systematic differences in the ownership structure of the insurers (e.g., Che et al., 2021; Leverty and Grace, 2018; Shim, 2017a; 2017b).

Table 12 describes the variables used in the regression analysis. *Own Table*.

A. **C**

3: Regression Results: Non-Linearity

Concentration: Industrials			- 0.144	- 0.147
			p = 0.662	p = 0.661
Concentration: Real Estate			- 0.354***	- 0.277***
			p = 0.001	p = 0.001
Concentration: Energy			0.217	0.502*
			p = 0.450	p = 0.077
Concentration: Consumer Staples			0.269*	0.209*
			p = 0.087	p = 0.059
Year Fixed Effects	Y	Y	Y	Y
Firm Clustered SE	Y	Y	Y	Y
Observations	21,038	20,949	21,038	20,949
R2	0.114	0.175	0.117	0.180
Adj. R2	0.114	0.174	0.116	0.179

Note: *p<0.1; **p<0.05; ***p<0.01

Table 13 shows the results of the OLS panel regressions (Tables 5 and 6) including a squared term of the sectoral HHI measure to test for non-linearity. Definitions of the variables are provided in Appendix A.4. Explanatory variables are lagged by one-year, the dependent variables are in logarithmic terms. Except for the indicator variables, the control variables are scaled to reduce the potential for structural multicollinearity. Variables with the prefix "Concentration" are indicators equal to 1 if an insurer has the maximum of its assets (percentage of sector-specific assets to total assets) in the given year concentrated in the respective sector. All panel regressions are estimated with year-fixed effects and clustered standard errors at the insurer level. Models (1) and (3) refer to the Z-score estimated by means of a three-year rolling window over the RoA observations, and Models (2) and(4) refer to the Z-score estimated by means of the insurers' entire time series of RoA observations. *Own Table*.

: Regression Results: Asset Type

	Dependent Variable			
	Z-score	Z-score (TS)	Z-score	Z-score (TS)
	(1)	(2)	(3)	(4)
HHI	0.508***	0.323***	0.462***	0.276***
	p = 0.000	p = 0.000	p = 0.000	p = 0.001
Size	0.051***	0.037***	0.052***	0.037***
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Leverage	- 0.169***	- 0.150***	- 0.169***	- 0.150***
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Non-Insurance Activities	- 0.038***	- 0.043***	- 0.037***	- 0.042***
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Underwriting Risk	- 0.152***	- 0.116***	- 0.150***	- 0.115***
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Reinsurance	0.010	0.073	0.007	0.072
	p = 0.850	p = 0.137	p = 0.886	p = 0.142
Age	0.110***	0.132***	0.110***	0.132***
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Group	0.107**	0.060	0.105***	0.058
	p = 0.007	p = 0.111	p = 0.007	p = 0.121
Ownership	- 0.043	- 0.102***	- 0.042	- 0.100***
	p = 0.296	p = 0.008	p = 0.307	p = 0.009

Concentration: Financials	0.131***	0.136***
	p = 0.005	p = 0.002
Concentration: Public Admin.	0.207***	0.209***
	p = 0.000	p = 0.000
Concentration: Industrials	- 0.109	- 0.135
	p = 0.727	p = 0.673
Concentration: Energy	0.614*	0.874***
	p = 0.083	p = 0.008
Concentration: Consumer Staples	0.195	0.1
		0.2

Leverage	- 0.198***	- 0.155***	- 0.196***	- 0.153***
	p = 0.000	p = 0.002	p = 0.000	p = 0.002
Non-Insurance Activities	- 0.149***	- 0.161***	- 0.146***	- 0.158***
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Underwriting Risk	- 0.208***	- 0.148***	- 0.205***	- 0.144***
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Reinsurance	0.163***	0.188***	0.174***	0.197***
	p = 0.010	p = 0.002	p = 0.006	p = 0.002
Age	0.081***	0.108***	0.078***	0.105***
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
Group	0.105**	0.074*	0.105**	0.073*
	p = 0.016	p = 0.072	p = 0.016	p = 0.074
Ownership	- 0.096**	- 0.115***	- 0.093**	- 0.114***
	p = 0.034	p = 0.006	p = 0.037	p = 0.006
Concentration: Financials			0.099*	0.065
			p = 0.067	p = 0.213
Concentration: Public Admin.			0.176***	0.161***
			p = 0.003	p = 0.005
Concentration: Industrials			- 0.062	- 0.170
			p = 0.854	p = 0.620
Concentration: Real Estate			- 0.275**	- 0.291***
			p = 0.029	p = 0.005
Concentration: Energy			0.201	0.388*
			p = 0.512	p = 0.051
Concentration: Consumer Staples			0.209	0.102
			p = 0.164	p = 0.339
Year Fixed Effects	Y	Y	Y	Y
Firm Clustered SE	Y	Y	Y	Y
Observations	16,236	16,167	16,236	16,167
R2	0.138	0.200	0.140	0.206
Adj. R2	0.137	0.199	0.139	0.205

Note: *p<0.1; **p<0.05; ***p<0.01

Table 15 shows the results of the OLS panel regressions for the sub-sample of P/C insurers. Definitions of the variables are provided in Appendix A.4. Explanatory variables are lagged by one year, and the dependent variables, the size variable, and the age variable are in logarithmic terms. Variables with the prefix "Concentration" are indicators equal to 1 if an insurer has the maximum of its assets (percentage of sector-specific assets to total assets) in the given year concentrated in the respective sector. All panel regressions are estimated with year-fixed effects and clustered standard errors at the insurer level. Models (1) and (3) refer to the Z-score estimated by means of a three-year rolling window over the RoA

: Regression Results: L&H Sub-Sample

: Regression Results: Firm Fixed Effects: Z-score Specification 1

	Dependent Variable	
	Z-score	Z-score
	(1)	(2)
HHI	0.162**	0.156**
	p = 0.025	p = 0.033
Size	0.136***	0.136***
	p = 0.000	p = 0.000
Asset Risk	0.214**	0.194**
	p = 0.010	p = 0.025
Leverage	- 0.154***	- 0.153***
	p = 0.000	p = 0.000
Non-Insurance Activities	- 0.050***	- 0.049***
	p = 0.000	p = 0.000
Underwriting Risk	- 0.094***	- 0.094***
	p = 0.000	p = 0.000
Reinsurance	0.009	0.007
	p = 0.890	p = 0.915
Age	- 0.131**	- 0.134**
	p = 0.013	p = 0.011
Group	0.065	0.019
	p = 0.861	p = 0.960
Ownership	- 0.003	- 0.005
	p = 0.952	p = 0.926
Concentration: Financials		- 0.036
		p = 0.307
Concentration: Public Admin.		- 0.027
		p = 0.494
Concentration: Industrials		- 0.358**
		p = 0.030
Concentration: Real Estate		- 0.263***
		p = 0.001
Concentration: Energy		- 4

in Appendix A.4. Explanatory variables are lagged by one year, and the dependent variables, the size variable, and the age variable are in logarithmic terms. Variables with the prefix "Concentration" are indicators equal to 1 if an insurer has the maximum of its assets (percentage of sector-specific assets to total assets) in the given year concentrated in the respective sector. Models (1) and (2) refer to the Z-score estimated by means of a three-year rolling window over the RoA observations. *Own Table*.

: Regression Results: Firm Fixed Effects: Z-score Specification 2

	Dependent Variable	
	Z-score (TS)	Z-score (TS)
	(1)	(2)
HHI	0.013	0.016
	p = 0.590	p = 0.508
Size	- 0.092***	- 0.093***
	p = 0.000	p = 0.000
Asset Risk	- 0.014	- 0.002
	p = 0.647	p = 0.935
Leverage	- 0.071***	- 0.071***
	p = 0.000	p = 0.000
Non-Insurance Activities	- 0.059***	- 0.059***
	p = 0.000	p = 0.000
Underwriting Risk	0.002	0.002
	p = 0.692	p = 0.697
Reinsurance	- 0.115***	- 0.115***
	p = 0.000	p = 0.000
Age	- 0.022	- 0.021
	p = 0.203	p = 0.224
Group	1.531***	1.522***
	p = 0.000	p = 0.000
Ownership	0.013	0.013
	p = 0.477	p = 0.481
Concentration: Financials		- 0.025**
		p = 0.022
Concentration: Public Admin.		- 0.035***
		p = 0.003
Concentration: Industrials		- 0.026
		p = 0.523
Concentration: Real Estate		- 0.098***
		p = 0.003
Concentration: Energy		- 0.104*
		p = 0.065
Concentration: Consumer Staples		- 0.087**
		p = 0.012
Year Fixed Effects	Y	Y
Firm Fixed Effects	Y	y
Firm Clustered SE	Y	Y

Observations	20,949	20,949
R2	0.939	0.939
Adj. R2	0.930	0.930

Note: *p<0.1; **p<0.05; ***p<0.01

Table 18 shows the results of the OLS panel regressions of the baseline model, including firm fixed effects in addition to the year-fixed effects and the clustered standard errors at the insurer level. Definitions of the variables are provided in Appendix A.4. Explanatory variables are lagged by one year, and the dependent variables, the size variable, and the age variable are in logarithmic terms. Variables with the prefix "Concentration" are indicators equal to 1 if an insurer has the maximum of its assets (percentage of sector-specific assets to total assets) in the given year concentrated in the respective sector. Models (1) and (2) refer to the Z-score estimated by means of the insurers' entire time series of RoA observations. *Own Table*.

: Regression Results: Firm Fixed Effects: Z-score Specification 2: Non-Logarithmic

Concentration: Consumer Staples		- 0.639 p = 0.296
Year Fixed Effects	Y	Y
Firm Fixed Effects	Y	y
Firm Clustered SE	Y	Y
Observations	20,949	20,949
R2	0.966	0.966
Adj. R2	0.961	0.961

Note: *p<0.1; **p<0.05; ***p<0.01

Table 19 shows the results of Table 18 but without a logarithmic specification. Definitions of the variables are provided in Appendix A.4. Explanatory variables are lagged by one year. Variables with the prefix "Concentration" are indicators equal to 1 if an insurer has the maximum of its assets (percentage of sector-specific assets to total assets) in the given year concentrated in the respective sector. Models (1) and (2) refer to the Z-score estimated by means of the insurers' entire time series of RoA observations. *Own Table*.

: Correlation Matrix of the Explanatory Variables

Acharya, V., Hasan, I., and Saunders, A. (2006). Should Banks Be Diversified? Evidence from Individual Bank Loan Portfolios. *Journal of Business*, 79(3), 1355–1412.

Acharya, V., Drechsler, I., and Schnabl, P. (2014). A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk. *Journal of Finance*, 69(3), 2689–2739.

Acharya, V. V., Pedersen, L. H., Philippon, T., and Richardson, M. P. (2017). Measuring Systemic Risk. *Review of Financial Studies*, 30, 2–47.

Allen, F., and Carletti, E. (2006). Credit risk transfer and contagion. *Journal of Monetary Economics*, 53(1), 89–111.

Bank of England [BoE]. (2014). Procyclicality and structural trends in investment allocation by insurance companies and pension funds. Discussion Paper.

Bank of England [BoE]. (2021). The PRA's methodologies for setting Pillar 2 capital. Statement of Policy.

Basel Committee on Banking Supervision. (1999). Risk Concentrations Principles. Regulatory Report.

Basel Committee on Banking Supervision. (2006). Studies on credit risk concentration, Working Paper No. 15.

Basel Committee on Banking Supervision. (2019). Overview of Pillar 2 supervisory review practices and approaches. Regulatory Report.

Bayar, T., Cornett, M. M., Erhemjamts, O., Leverty, T., and Tehranian, H. (2018). An examination of the relation between strategic interaction among industry firms and firm performance. *Journal of Banking & Finance*, 87, 248-263.

Beck, T., De Jonghe, O., and Mulier, K. (2022). Bank sectoral concentration and risk: evidence from a worldwide sample of banks. *Journal of Money, Credit and Banking*, 54(6), 1705-1739.

Becker, B., & Ivashina, V. (2015). Reaching for Yield in the Bond Market. *Journal of Finance*, 70(5), 1863–1902.

Berry-Strket.

Eling, M., Gatzert, N., and Schmeiser, H. (2009). Minimum standards for investment performance: A new perspective on non-life insurer solvency. *Insurance: Mathematics and Economics*, 45(1), 113-122.

Eling, M., and Jia, R. (2008). Business failure, efficiency, and volatility: Evidence from the European insurance industry. *International Review of Financial Analysis*, 59, 58-76.

European Commission. (2021). Proposal for a Directive of the European Parliament and of the Council amending Directive 2009/138/EC as regards proportionality, quality of supervision, reporting, long-term guarantee measures, macro-prudential tools, sustainability risks, group and cross-border supervision, COM(2021) 581 final, Brussels, Sept. 22, 2021.

European Insurance and Occupational Pensions Authority [EIOPA]. (2014). The underlying assumptions in the standard formula for the solvency capital requirement calculation. Regulatory Report.

European Insurance and Occupational Pensions Authority [EIOPA]. (2018b). Failures and near misses in insurance. Regulatory Report.

European Insurance and Occupational Pensions Authority [EIOPA]. (2018c). Solvency II tools with macroprudential impact. Regulatory Report.

European Insurance and Occupational Pensions Authority [EIOPA]. (2019a). European Insurance Overview 2019. Dataset and Regulatory Report, available at EIOPA's insurance statistics section.

European Insurance and Occupational Pensions Authority [EIOPA]. (2019b). Discussion Paper on Systemic Risk and Macroprudential Policy in Insurance, Discussion Paper EIOPA-BoS-19/131.

European Insurance and Occupational Pensions Authority [EIOPA]. (2020). European Insurance Overview 2020. Dataset and Regulatory Report, available at EIOPA's insurance statistics section.

European Systemic Risk Board [ESRB]. (2020). Enhancing the macroprudential dimension of Solvency II. Regulatory Report.

Fabozzi, F. J., Kynigakis, I., Panopoulou, E., and Tunaru, R. S. (2020). Detecting bubbles in the US and UK real estate markets. *Journal of Real Estate Finance and Economics*, 60, 469-513.

Financial Stability Oversight Council [FSOC]. (2013). Basis for the Financial Stability Oversight Council's Final Determination Regarding Prudential Financial, Inc. Regulatory Report.

Gordy, M. B. (2003). A risk-factor model foundation for ratings-based bank capital rules. *Journal of Financial Intermediation*, 12(3), 199–232.

Gordy, M. B., and Lütkebohmert, E. (2013). Granularity adjustment for regulatory capital assessment. *International Journal of Central Banking*, 9(3), 33–71.

Grippa, P., and Gornicka, L. (2016). Measuring Concentration Risk - A Partial Portfolio Approach. IMF Working Paper 16/158.

Gürtler, M., Hibbeln, M. T., and Vöhringer, C. (2010). Measuring Concentration Risk for Regulatory Purposes. *Journal of Risk*, 12(3), 69–104.

International Association of Insurance Supervisors [IAIS]. (2018a). Holistic Framework for Systemic Risk in the Insurance Sector, Public Consultation Document.

International Association of Insurance Supervisors [IAIS]. (2018b). Risk-based Global Insurance Capital Standard Version 2.0, Public Consultation Document.

International Association of Insurance Supervisors [IAIS]. (2020). Level 2 Document: ICS Version 2.0 for the monitoring period, Regulatory Report.

UBS. (2023). Global Real Estate Bubble Index, Chief Investment Office GWM, Investment Research, Sept. 2023.

Urban, M., Dittrich, J., Klüppelberg, C., and Stölting, R. (2004). Allocation of risk capital to insurance portfolios. *Blätter der DGVFM*, 26(3), 389–406.

U.S. Department of Justice and Federal Trade Commission. (2010). Horizontal Merger Guidelines.

Van Oordt, M., and Zhou, C. (2018). Systemic risk and bank business models. *Journal of Applied Econometrics*, 34(3), 365–384.

Wagner, J. (2014). A note on the appropriate choice of risk measures in the solvency assessment of insurance companies. *Journal of Risk Finance*, 15(2), 110-130.

Wagner, W. (2010). Diversification at financial institutions and systemic crises. *Journal of Financial Intermediation*, 19(3), 373–386.

Weiß, G., and Mühlnickel, J. (2014). Why do some insurers become systemically relevant? *Journal of Financial Stability*, 13, 95–117.