

Structure and Complexity of Global Insurance Groups¹

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Abstract

The top 100 international (re)insurance groups account for 85% of the global insurance assets and thus are the driving force of the global insurance supply. Yet little is known about their internal structure, business focus, and international footprint. We fill the gap by providing the first comprehensive analysis of the structure and complexity of the global insurance groups. We construct and analyze a novel dataset on the corporate structure of the top 100 global insurance groups with headquarters located in 21 countries and 8,000 subsidiaries located in 117 countries and offshore territories. We document how the level of internationalization and the business focus of foreign subsidiaries vary across headquarters regions as well as advanced and emerging economies. Then we examine the measures of business and geographic complexity of insurance groups and relate them to insurers' performance and their contribution to global risk sharing.

Keywords: Global Insurance Market, Insurers' Corporate Structure and Complexity, Financial Regulation.

Relevant JEL codes: G01, G23, G28, G22, G32, O16.

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1 Introduction

The top 100 world’s largest (re)insurance groups are the driving force of the global insurance market. In aggregate, top insurance groups account for 85% of the global insurance assets and operate internationally. Yet, little is known about their structure, complexity, and global footprint. The objective of the paper is to fill this gap. We construct a novel dataset that contains detailed information about each group’s corporate structure (i.e., its corporate tree), the geographical location, and the business profile of the group’s subsidiaries in 2018. We collect information on the top 100 largest insurance groups (by asset size in 2018) that are headquartered in 21 countries, of which 17 are advanced economies, and 4 are emerging markets. These groups are composed of about 8,000 subsidiaries that operate in 117 countries and offshore territories.

We employ the dataset to unveil a substantial diversity in the business models of insurance groups in terms of structure, business, and international focus of subsidiaries. Our analysis reveals the particularities of insurance business models across the major insurance markets in Asia, Europe, and North America. Then we construct measures of business and geographic group complexity and explore how complexity is related to group size, performance, and ability to contribute to global risk sharing. We also explore the systemic risk implications of the insurance group structure. That is, we relate the geographic and business structure of the group to its operation in multiple insurance prudential regulatory regimes and connect the regulatory complexity to the potential costly resolution in case of failure during market stress. We also identify the potential for the cross-regional transmission of shocks through the network of domestic and foreign subsidiaries.

Our findings can be summarized as follows. Most of the foreign business of the major international insurance groups remains in advanced economies. That is, even though insurance groups in some regions like Europe and Japan have many foreign subsidiaries, these subsidiaries operate mainly in the UK or the US insurance markets. At the same time, the extent of internationalization of insurance groups varies significantly across regions. European and Japanese insurance groups have the highest share of foreign subsidiaries. By contrast, the US and Chinese groups are domestically focused with very limited exposure to other insurance markets. Furthermore, we find that international insurance groups actively use offshore centers in their operations. Japanese insurance groups have the highest share of offshore subsidiaries accounting, on average, for 7% of all subsidiaries. Offshore subsidiaries are also common for European insurance groups, with the share of 5% and the largest absolute aggregate number of legal entities.

The major insurance groups are highly diverse in terms of their business focus. We classify the business focus of subsidiaries into four categories, (i) the core insurance business of life and non-life insurance and insurance intermediation (brokerage); (ii) reinsurance; (iii) other financial services, and (iv) non-financial businesses. We find that the business focus of the insurance groups in Continental Europe is mainly in the core insurance business and reinsurance, both domestically and internationally. By contrast, the US and the Japanese insurance groups have a significant number of non-core and often non-financial subsidiaries, creating a conglomerate structure where remotely related businesses reside under the insurance headquarters (HQ). The insurance groups in the UK have distinct business models for their domestic and international subsidiaries. While domestic subsidiaries concentrate on life insurance, reinsurance, and financials, the international subsidiaries have a strong presence in insurance brokerage and non-financial sectors. The insurance groups in China emerge as providers of broader financial services that often extend beyond insurance. Chinese insurance groups also have a distinctively low share of reinsurance subsidiaries compared to groups in advanced economies.

Next, we quantify insurance group complexity across several dimensions and relate complexity to group size and performance. Our indicators of complexity include the total count of levels of subsidiaries in the group corporate structure, the ratio of insurance and non-insurance business as well as insurance and other financial businesses, and the Herfindahl indices of geographic and business complexity. Following the analysis of Cetorelli and Goldberg (2014), who analyze the complexity of bank holding companies operating in the US, we explore the linkages between the insurance group size and its complexity. The main finding of Cetorelli and Goldberg’s (2014) analysis is that the bank’s complexity is unequal to its size. That is, asset size is a poor predictor of bank group complexity. We perform a similar analysis for the sample of the major insurance groups and find that the link between complexity and size is even weaker for insurance companies than banks.

We also explore how group complexity is related to group performance using common market characteristics of performance, Tobin Q, and return on assets. We find that insurance groups with higher business complexity, i.e. higher diversity of businesses between insurance and non-financial subsidiaries, obtain higher market valuations. Furthermore, it is the non-financial subsidiaries that contribute to higher valuations, while the share of non-insurance financial businesses has no significant effect. By contrast, market valuations are not affected by the insurance group size and geographic complexity. Besides providing the first assessment of the impact of group structure on performance, our results are complementary to the seminal paper by Laeven and Levine (2007), who document the diversification discount when banks combine lending and non-lending financial activ-

ities. We document the opposite effect where business complexity yields a diversification premium to global insurance groups.²

The insurance group structure can enhance the insurance group’s ability to provide global risk sharing by diversifying risks internationally. Or, it can be shaped to overcome the hurdles of multiple fragmented domestic insurance supervisory regimes and capital controls. We analyze the relevance of these factors for the group structure. As a starting point, we identify the domestic insurance market attributes that explain the decision of an international insurance group to operate there their subsidiaries. Our results for the insurance market corroborate with the findings of the previous research in corporate finance (La Porta et al, 2000). We find that financial development, the quality of the regulatory regime, and insurance density in the market are positively related to the number of foreign insurance subsidiaries established by the major insurance groups. Finally, we provide some initial analysis on whether the group structure is set up to overcome the hurdles of the regulatory regimes. Relatedly, we analyze the drivers of the decision to set up offshore subsidiaries by major insurance groups.

Furthermore, we explore whether complexity enables insurance groups to resolve the protection gap. We address the question by analyzing the impact of groups’ complexity on the protection gap, resilience index, and total exposure risk at the country level. Additionally, we enhance our results by addressing the expansion strategy of globally dominant insurance groups by market share. We find that business complexity is an important element of insurance groups that aids in solving the protection gap, unlike geographical complexity. Besides, insurance groups resolve the protection gap through their expansion strategy by acquiring higher market share, primarily in developing regions. The groups that, on average, have higher market shares across different countries target countries with lower resilience to withstand risk.

Lastly, we explore whether the diversity of risk profiles and investment opportunities for various insurance business lines leads to efficient capital transactions and additional value. Our findings indicate that diversity can be harmful to efficient capital allocation.

Our study is the first comprehensive analysis of the global insurance groups and the structure of the global insurance market. Only a few previous studies analyze the international insurance market, e.g., Berry-Stolzle et al (2013), Cole et al (2012), Outreville (2008), relying on earlier smaller cross-country datasets of insurers on the legal entity

² An important methodological difference between Laeven and Levine (2007) and our analysis is that their analysis is performed on the legal entity basis while we measure performance on the level of the HQ of an insurance group.

basis without regard to the group structure.³ The lack of analysis of the modern global insurance market contrasts with the growing literature on global banks. For example, in a recent review of the research on global banks, Claessens (2016) cites about 150 research papers on the topic. The international banking literature has demonstrated that while global banking brings the benefits of global risk sharing during the period of stress in the host market, it also introduces risks related to international shock transmission. Our main contribution in the current paper is to start filling the gap in the analysis of the global insurance market.

Understanding the functioning of the global insurance market is important for several reasons. Like global banks, global insurers have expanded beyond national borders and are highly interconnected with the capital markets. As discussed in Herring and Carmassi (2012), while increasing complexity is a response of financial conglomerates to deal with agency problems arising from asymmetric information, costly financial distress, taxes, and regulation, complexity may make institutions too complex to fail. In insurance, the issue of the complexity of corporate structure is magnified by the fragmented insurance regulatory regimes and the weaknesses of group supervision. As we discuss in more detail below, even in advanced economies, insurance groups operate under diverse domestic regulatory regimes. Unlike Basel III international minimum requirements in banking, no such standard is yet developed for insurance companies.

Investors, insurers, and reinsurance hold over 30 trillion dollars of global assets under management. Insurers' business models have real effects on their asset allocation and can contribute to systemic risk (Chodorow-Reich et al (2020), Ellul et al (2021), Du et al. (2023)). Because financial conglomerates' corporate structure affects their business models, it may have real effects on insurers' asset allocation and insurance groups' contribution to systemic risk. Therefore, analysis of the group structure can improve the understanding of the transmission channels of systemic shocks. For example, our analysis indicates a potential transmission channel of market shocks affecting insurers' asset valuations and investment returns from the US market to Japan and Europe.

As risk managers and risk carriers, (re-) insurers provide \$5 trillion of world premium volume of insurance coverage. In particular, it permits businesses and households to insure the financial consequences of intensified natural disasters due to climate change. However, in 2018 the global protection gap, that is, the ratio between non-insured and total losses, for natural catastrophes was 76% - meaning that only 24% of losses are insured (Ito and McCauly, 2019; Swiss Re, 2019). The puzzle is that even in the most developed

³ Berry-Stolze et al (2013) analyze a sample of about 1700 companies in 2005-2007 without regard to the group structure; Outreville (2008) considers a sample of 45 groups in 2003 but has no information about the group structure; Cole et al (2012) analyse a sample of US reinsurers in 1998-2008.

insurance markets in advanced economies, the gap is 65%. Understanding the global insurance market structure can help to identify the supply imperfections contributing to the gap.

The rest of the paper is organized as follows. The next section reviews the mechanisms of intragroup capital market and risk sharing. Section 3 describes the dataset and provides some basic summary statistics. Section 4 reports the geographical and line of business characteristics of the global insurance groups. Section 5 analyzes simple measures of group complexity and reports how these measures are related to the insurance group size. Section 6 provides an analysis of the relationship between group structure and complexity characteristics and the market-based measures of group performance. Section 7 provides a few initial analyses of the group complexity and global risk sharing. Section 8 examines whether the complexity of insurance groups resolves the protection gap through their choice of expansion strategy. Section 9 focuses on the effect of diversity in insurance companies' business lines on the efficiency of capital allocation. The conclusion follows.

2 Why Does Insurance Group Structure Matter?

Risk pooling and diversification are at the core of the insurance business. In the seminal paper, Borch (1962) develops the framework for the analysis of optimal risk sharing. It explains that the maximum capacity for risk-bearing in the economy is attained when individual insurers trade risks with each other through an active reinsurance market. Then the insurance industry can sustain the maximum loss equal to its aggregate capacity, i.e. the total amount of the insurance industry equity capital.

In practice, most of the risk sharing in the global insurance industry is achieved within the largest insurance groups using a network of their subsidiaries rather than third-party reinsurers. Among the top 100 insurance groups in our sample, 97 are the primary insurance groups, and only 3 are the reinsurance groups. Also, the size of the balance sheet of the largest insurance groups is multiples of the size of reinsurers. In fact, the size of each of the three major reinsurers in our sample ranges about 20-45% of the size of the largest primary insurance groups. Of course, insurance groups do not operate in isolation and transfer risk between each other. Furthermore, insurance groups participate in a large variety of different businesses besides insurance that may either diversify the risks or introduce additional co-movements with the financial markets. For these reasons, analysis of the group structure provides a significant step toward understanding the mechanisms of global risk sharing.

The insurance group structure creates an internal capital market for the individual subsidiaries. The extensive theoretical literature on the internal capital markets has identified several mechanisms that reduce financial frictions, facilitate risk sharing and capital management, or introduce additional agency costs. One of the advantages of the internal capital market is that it diminishes the information asymmetries among subsidiaries in the group (see, e.g., Diamond (1991), Rajan (1992), Saunders and Walter (1994), and Stein (2002)) and improves the monitoring incentives among its members (Diamond, (1994)). As a result, it creates a wedge between internal and external financing. However, the dark side of the internal capital market is that it makes it more difficult to design appropriate managerial incentive schemes and align incentives between the corporate group insiders and outsiders (Scharfstein and Stein (2000)).

Internal capital markets of large insurance groups can also fill the void in host countries where the domestic financial capital markets are poorly developed, similar to the role of internal capital markets of multinational corporations expanding to emerging markets (Desai, Foley and Hines (2004)). In countries with lower levels of financial development, which are typically also the ones with the highest protection gaps (Swiss Re, 2019), large insurance groups may be better positioned to supply insurance capacity compared to smaller domestic players. However, in these markets, the international groups may also adopt more risky strategies due to lower reputation costs and be subject to less risk-sensitive supervisory regimes.

The group structure affects the group risk-bearing capacity due to the limited liability protection of the subsidiaries and the holding company, which affects the costs of financial distress and, therefore, the cost of external financing (Bianco and Nicodano, 2002). Luciano and Nicodano (2014) and Nicodano and Regis (2019) analyze the corporate structure in which the holding company provides conditional guarantees to the subsidiaries and therefore increases the joint value under a tax-bankruptcy trade-off. The corporate structure with separate subsidiaries also provides a mechanism to isolate the group from fat-tail risks of some exposures. Separating some risks in a subsidiary that can become insolvent improves the solvency of the other subsidiaries in the insurance group (Ibragimov, Jaffee and Walden 2009, 2011; Jaffee and Russell, 1997; Zanjani, 2002).

3 Data

We build a comprehensive sample of the major insurance groups that enables to explore the internal organization of groups and their international presence. The unique feature of our dataset which sets us aside from a few earlier studies of the international

insurance market (e.g., Altuntas et al. 2015, Berry-Stolze et al. 2013, Outreville 2008, Cole et al 2012.) is that we collect information on the corporate structure of insurance groups. These data permit us to analyze the global insurance market through the lenses of the internal organization and interaction among various entities which form part of an insurance group.⁴

3.1 Sample Description

The sample consists of the top 100 largest global (re)insurance groups by total assets at the end of 2017. Most of these groups have the headquarters (HQ) holding company which is an insurer. This applies to 91 internationally active insurance groups, i.e. life and health, property and casualty, reinsurance, insurance brokerage, or multiline. The other 9 are large subsidiaries (subgroups) of non-insurance corporate groups, including asset management (3), conglomerates (4), and managed health care (2). Though the latter category is part of a larger corporate structure rather than an independent insurance group, the significance of these companies for the global insurance market is often larger than that of some smaller insurance groups. This justifies their inclusion in our dataset. One prominent example of this kind is Warren Buffet’s Berkshire Hathaway, where large insurance and reinsurance subgroup is part of a non-financial conglomerate in the US. Its reinsurance operations rank it as one of the top five global reinsurance players. Another example is Japan Post Insurance which is a subsidiary of Japanese Post Holding, a national postal service. Yet, it is one of the largest life insurance companies in Japan.

Our sample is representative of the global insurance market. The total assets of insurance companies in the sample are USD 26 trillion. The total consolidated assets of the corresponding groups are more than USD 28 trillion. The discrepancy arises due to different methods of insurance consolidation.

The corporate structure and financial information is obtained from the S&P Global Market Intelligence platform. In (rare) cases of S&P MI gaps, the complementary information on total assets was obtained from the annual reports of the companies. The estimates of the domestic and global insurance market size are calculated using the OECD Insurance Statistics. OECD collects data for 35 OECD member countries⁵ and 27 non-member

⁴ This and the next sections build on and extend the earlier joint initial work with Kristina Micic.

⁵ Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

economies⁶. The assessment of insurance market penetration and the insurance coverage gaps relies on the data compiled by OECD and Swiss Re.

S&P Global Market Intelligence platform (S&P MI) reports the group’s organizational chart and its major subsidiaries and/or major investments. Using these data, we construct corporate hierarchies (corporate trees) for each of the insurance groups (or subgroups in the case of the non-insurance parent company). A hierarchy is a vertical ownership and affiliate structure where the ultimate parent of a group, i.e. its HQ, has either a direct or indirect connection with its subsidiaries. In the direct connection, the HQ directly owns the company. In the indirect connection, a company is owned by an entity located at a level below HQ which in turn can be either directly owned by the HQ or can have another immediate parent.

In the corporate structure, the *nodes* of the tree are individual companies and the *direct connections* are the ownership links between the two companies. We also define a company *level* as its distance, measured by the number of connections, from the HQ. The companies directly owned by the HQ are on the first level, the companies owned by them are on the second level, etc.

There are two caveats on the completeness of the corporate trees. The group trees reported by S&P MI consist only of insurance companies and parents of insurance companies. It implies that in case an insurance entity owns a non-insurance entity which in turn owns another insurance entity, the latter one would not be recorded in our description of a corporate tree. Another feature of the data is that subsidiaries and affiliates are included in the corporate hierarchy either if 50% or more are owned by the parent with a) “an intent to derive operational or synergistic value from the company” or b) “only an intent to derive financial value from the company”; or if less than 50% is owned by the parent but the parent “has effective control of the company” (S&P MI).

To illustrate the nature of the dataset, we present one sample observation, a group corporate tree of Royal London Mutual Insurance Society Ltd, in Figure 1. Each of the groups in our sample is recorded in a similar format. The Royal London Mutual group consists of HQ and 14 subsidiaries. It has 6 subsidiaries reporting directly to HQ, which we label Level I subsidiaries. Three of them have subsidiaries down the corporate tree, with 5 subsidiaries located on Level II, 2 located on Level III, and one located on Level IV. As we discuss further in the Summary Statistics section below, this example represents one of the simpler trees.

⁶ Argentina, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Hong Kong SAR, India, Indonesia, Lithuania, Malaysia, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Russia, Singapore, South Africa, Sri Lanka, Thailand, Tunisia and Uruguay.

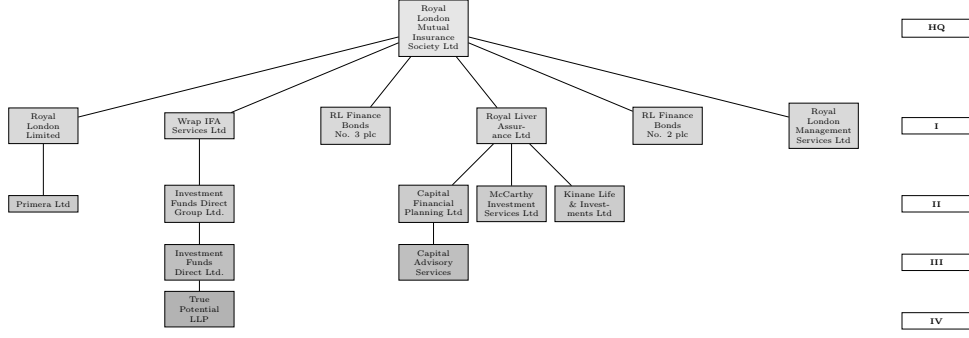


Figure 1: *Corporate Tree Example.*

This figure presents a sample observation of the corporate tree of Royal London Mutual Insurance Society Ltd, comprising the HQ and 14 subsidiaries. Among them, six Level I subsidiaries report directly to the HQ. Three of these Level I subsidiaries have subsidiary entities, with five on Level II, two on Level III, and one on Level IV. This example shows a simpler tree in the dataset. For further analysis and detailed statistics, one can refer to the results provided in the Summary Statistics section.

For each company in a corporate tree, we collect information about its country of residence, industry and identification number, type of ownership (i.e. majority subsidiary or majority investment), and ownership by the immediate parent (in percent). In addition, where possible, we collect the company’s balance sheet and income statement information, its rating by the major rating agencies, and a ticker if it is publicly traded. We use all available company identities to be able to enrich the data in future research. Whenever possible, we record a Legal Entity Identifier (LEI) of a company.⁷ At the group HQ level, we collect balance sheet and income statement information as presented in the insurance groups’ annual reports.

There is substantial geographic and business diversity among the subsidiaries of the top insurance groups. On aggregate, the subsidiaries operate in 117 countries and a variety of insurance and non-insurance businesses. To build the indices of business and geographic complexity of a group, we condense the information in broad yet meaningful categories. We apply the geography and industry classification presented in Table 1 and in Appendix A.1.⁸

3.2 Summary Statistics

Our sample provides a comprehensive overview of the global insurance industry. The total assets of insurance companies in our sample are USD 26 trillion. The total consolidated

⁷ We refer to the Financial Stability Board for further information on LEI, <https://www.fsb.org/work-of-the-fsb/policy-development/additional-policy-areas/legalentityidentifier/>

⁸ In geography classification in Appendix A.1, we list only those countries in which the top 100 insurers have active subsidiaries. Countries listed are only those where active subsidiaries of the sampled groups are present.

Insurance	Multiline, Property & Casualty, Life & Health, Insurance Brokerage Companies
Reinsurance	Reinsurance companies
Other Financial	Asset Management Companies, Banks, Mortgage Brokers, Hedge Funds, Other Companies Involved in Financial Services provision
Other Non-Financial	All others not classified in the above categories, including those for which the industry is unknown (unknown accounts for only 8% of the total count of subsidiaries)

Table 1: *Industry Classification.*

This table provides a business classification system for the subsidiaries of the sampled insurance groups, categorizing them into four main classes: Insurance (including Multiline, Property & Casualty, Life & Health, and Insurance Brokerage Companies), Reinsurance, Other Financial (comprising Asset Management Companies, Banks, Mortgage Brokers, Hedge Funds, and others in financial services), and Other Non-Financial (covering subsidiaries in miscellaneous industries, including those with unknown industry classification). This classification aids in analyzing the business complexity and diversification among the subsidiaries across different sectors later on in the paper.

assets of the corresponding groups exceed USD 28 trillion. For comparison, the total asset size of the global insurance market is around USD 25 trillion in 2016 (OECD, 2016).

The headquarters of the 100 groups in the sample are located in 21 different countries. Figure 2 reports the complete set of the HQ locations by country and the total consolidated assets of groups with HQ located in each country. It reveals that 82% (by number count) of global insurance groups are headquartered in advanced markets in Asia, Europe, and North America. Their assets represent 85% of the total assets of the groups in the sample. Among the emerging markets, insurance groups headquartered in China account for 52% of total assets in emerging markets. The insurance market is rather concentrated. In the sample, the top 9 insurance groups accounted for 25% of the consolidated total assets the sample.⁹

The corporate trees of the top 100 insurance groups consist of more than 8,000 subsidiaries located in 117 countries and territories. Figure 2 provides the summary statistics of the distribution of headquarters.

As we will discuss in detail below, there is a lot of diversity in the structure, business focus, and the internationalization of the insurance group. Table 2 reports that, on average, the insurance group corporate tree consists of five levels though its depth can reach up to 15 levels. However, as Figure 3 reveals, for 88% of groups, the structure does not exceed five levels. In terms of the number of subsidiaries in the group, there is a significant degree of variation around the average of 82 subsidiaries. As for the level of internationalization, foreign subsidiaries average at 46, which is slightly higher than half of the total number

⁹ The largest 10 insurance groups are Allianz (Germany), Assicurazioni Generali (Italy), Aviva (UK), AXA (France), Legal and General Plc (UK), MetLife (USA), Nippon Life (Japan), Ping An (China), Prudential Financial (USA), Prudential plc (UK).

of subsidiaries. Groups are also very diverse in terms of their business focus, measured by the number of non-insurance subsidiaries.

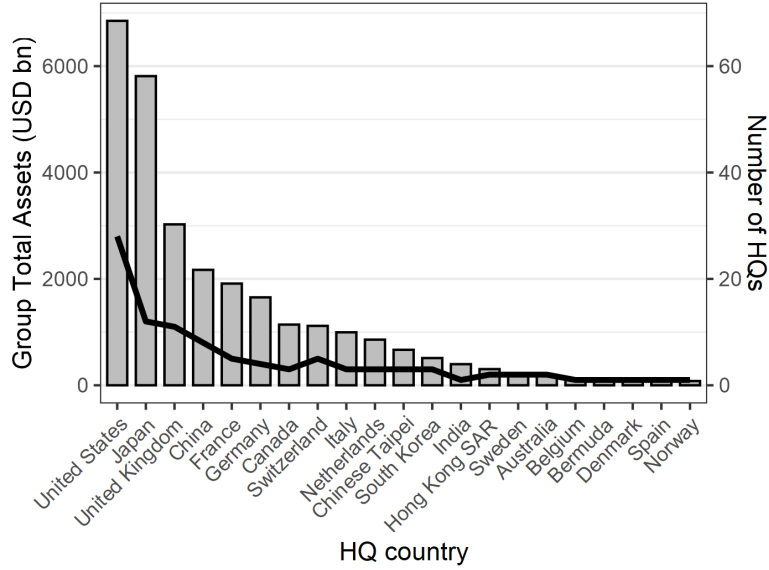


Figure 2: *HQ Geography.*

The figure presents the distribution of the number of headquarters (HQs) and total group assets, in USD billion, of the top 100 insurance groups in the sample, encompassing 21 different countries. The figure provides summary statistics derived from over 8,000 subsidiaries spanning 117 countries and territories. Sources: S&P Market Intelligence, companies' websites.

	Average	Standard Deviation	Minimum	Maximum
Levels	5	3	1	15
No. of subsidiaries	82	125	1	980
No. of subsidiaries outside home country	46	68	0	317
No. of subsidiaries in non-insurance business	38	90	1	746

Table 2: *Summary Statistics on Group Tree Structure.*

This table provides summary statistics on the structure of insurance groups. The table focuses on the analysis of mean, standard deviation, minimum and maximum for levels, number of subsidiaries, number of subsidiaries outside of the home country, and number of subsidiaries in the non-insurance business.

4 Distinctive Features of Global Groups

In this section, we present key stylized facts about the diversity of the structure of the major insurance groups in terms of their international presence and business focus. To illustrate the richness of the business models and organization structures, we spotlight the insurance groups with HQs in the core insurance markets – China, Continental Europe,

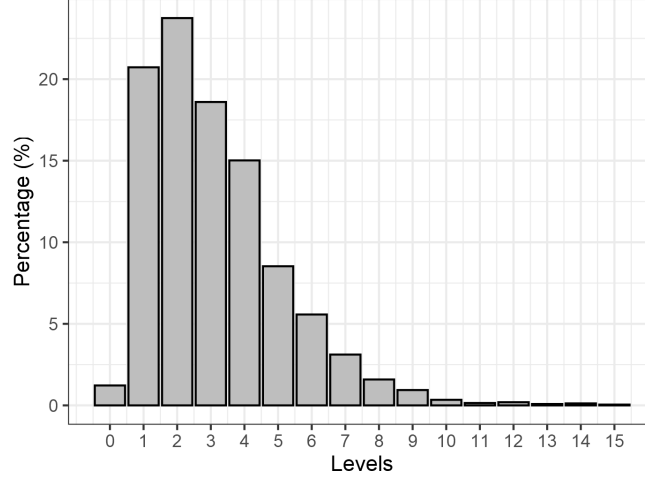


Figure 3: *Distribution of Majority Subsidiaries/Investments Across Levels.*

This figure presents the distribution of density for the levels within insurance groups. Additionally, this figure helps to explore the hierarchical organization of subsidiaries within insurance groups and provides valuable information about the prevalence of different levels across the sampled insurance entities.

Japan, United Kingdom, and United States.¹⁰

4.1 International Footprint of Insurance Groups

The major insurance groups vary a lot in the degree of internationalization, i.e. the importance of foreign subsidiaries in the corporate structure. Figure 4 depicts the distribution between home and foreign subsidiaries for groups with HQs in the core insurance markets. The bars show in percentage the distribution of the aggregate number of the domestic and international subsidiaries for the regional insurance groups. On the two extremes of the range are the insurance groups headquartered in Japan and the US. While the Japanese groups, on average, have 80% of international subsidiaries, the US groups have only 20% of the foreign subsidiaries. In the middle of the range are the EU and the UK insurance groups, which split their business equally between the domestic and international markets. As for the Chinese insurance groups, their focus is 70% domestic and 30% international. The domestic market focus of the Chinese HQ insurance groups can be explained by the low level of maturity and the growth potential of the insurance markets in China. Similarly, the Japanese insurance groups operate in a mature saturated market and thus need to expand internationally to new markets for growth. At the same time, the contrast between the internationalization of the European and the US insurance groups is a bit puzzling, given the similarities between the level of their economic and financial development and the degree of integration into the global economy.

¹⁰ For a comprehensive view of the Chinese market, we enrich it by including insurance groups in Hong Kong, Macao and Taiwan.

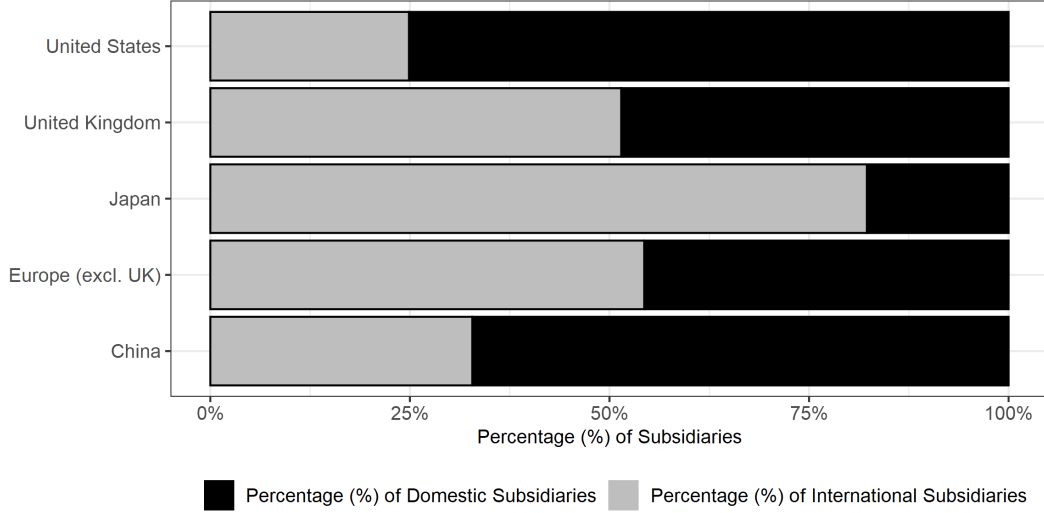


Figure 4: *Subsidiaries Home and Abroad for Selected HQ Locations.*

This figure presents the distribution of home and foreign subsidiaries for major insurance groups with headquarters in core insurance markets. The bars display the percentage distribution of the aggregate number of domestic and international subsidiaries for regional insurance groups. The figure highlights varying degrees of internationalization and strategic market focus among these groups, as depicted by the height of the bars representing the proportion of subsidiaries in each category. China includes Hong Kong SAR, Chinese Taipei, and Macao SAR.

Zooming into the destinations where the major insurance groups establish their foreign subsidiaries, Figure 5 presents the aggregate location matrix for groups in the core markets. Different sections of the pie chart correspond to the share of subsidiaries in the locations. Figure 5 reveals that the most popular location for foreign subsidiaries of the Japanese and European insurance groups is the US. Among all foreign subsidiaries, 47% of subsidiaries of Japanese insurance groups and 39% of subsidiaries of the European insurance groups operate in the US insurance market. For comparison, the share of the US-located subsidiaries of the UK insurance groups is only 14%. By contrast, the groups in the core insurance markets operate less than 0.5% of their subsidiaries in Japan. Figure 5 also indicates the strong degree of interconnectedness between the insurance markets in Continental Europe and the UK, with a higher exposure of the UK insurance group to Continental Europe (16%) compared to Continental Europe to the UK (11%). The exposure of the US to each of the European regions, the EU and the UK, is about 8%.

We find that the current network of interconnections in the global insurance market is highly asymmetric. While the Japanese and the European groups have significant exposure to the US, the US and Chinese, and UK insurance groups have limited connections to the other core insurance markets. Thus, while the shocks in the US can have a significant effect on the operations of the domestic and foreign subsidiaries of Japanese and European insurers, shocks in Japan and Europe are likely to have a limited direct impact on the insurance markets in the US. However, shocks in Japan and Europe may

have a significant impact on the operations of the subsidiaries of the insurance groups from these countries in other markets, particularly emerging economies. The structure of interconnections among the insurance groups in the core insurance markets unveiled by our data raises interesting questions about the role of the global insurance groups in the international transmission of domestic market shocks and monetary policy.

To run a parallel between our findings and the analysis of the propagation of market shocks and domestic monetary policy through global banks (see, e.g., Cetorelli and Goldberg (2012)), the mechanisms of transmission are likely to be different for insurers than for banks. Market volatility and monetary policy rates affect insurers' assets by changing the investment returns and liabilities by changing the regulatory reserves (Niehaus (2018), Koijen and Yogo (2021, 2015)). Then reallocation of capital within insurance groups to support underperforming or undercapitalized subsidiaries in one market can translate into real economic effects in the other part of the group by affecting the insurance supply or by asset reallocations in insurers' investments.

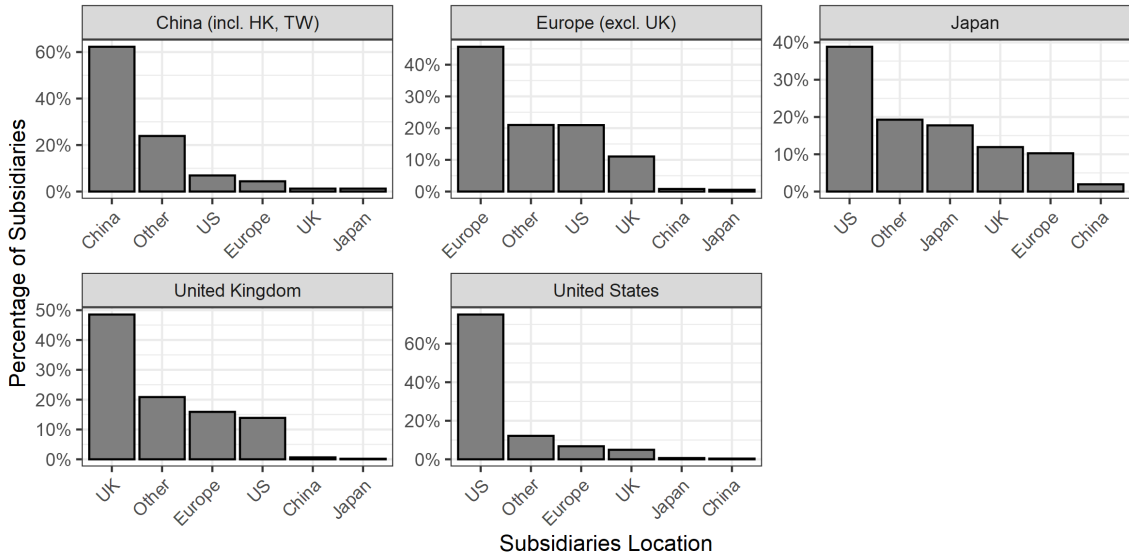


Figure 5: *Location Matrix for Major Insurance Markets.*

This figure depicts multiple bar charts illustrating the distribution of foreign subsidiaries for Japanese, European, UK, US, and Chinese insurance groups in major insurance markets. In particular, this figure provides valuable information on the regional preferences and international strategies of major insurance groups, emphasizing the significance of the US and Chinese insurance markets.

Another aspect of the structure of the global insurance groups relevant for assessing their ability to contribute to global risk sharing is the distribution of the foreign subsidiaries between advanced and emerging markets. Figure 6 reports the location matrix of the insurance groups in the major insurance markets across various geographies. We find that most subsidiaries of the insurance groups remain in advanced economies rather than exploring emerging markets. The highest share (and count) of subsidiaries in emerging markets are owned by the European insurance groups and amount to 17% of subsidiaries.

The share of subsidiaries in emerging markets among the Japanese and the US insurance groups is only 7%.

Figure 6 also unveils a considerable role of offshore subsidiaries in the functioning of the global insurance groups. The use of offshore locations is particularly pronounced among the Japanese groups, with 7% of offshore subsidiaries among all subsidiaries and followed by insurance groups in Continental Europe with 5% of offshore subsidiaries. Though at the lower level of 3%, offshore subsidiaries are also common in insurance groups in the other core markets. Further analysis is needed to explain the differential intensity of using offshore subsidiaries by insurance groups across markets. However, the likely purpose of these subsidiaries is tax and legal structure optimization.

In sum, our data show that there is a substantial variation in the international focus of the major insurance groups. While Japanese, European, and UK insurance groups are very international, with a diverse set of host countries for their subsidiaries, the US and Chinese insurance groups are primarily focused on their domestic markets. Also, we find that insurance remains the advanced economies business. Even though global insurance groups have subsidiaries in emerging markets, the share of these subsidiaries in the corporate structure of major groups is relatively small, and their position in a group is peripheral. We provide further analysis of the factors that affect the insurance group entry in emerging markets in Section 6. The analysis also uncovers a substantial use of offshore centers in the core insurance business.

4.2 Business Focus of Insurance Groups

The diversity of the business focus of subsidiaries within the insurance group is another important element of the group structure. Figure 7 reports the business area of subsidiaries by location aggregated to advanced and emerging economies and offshore centers. It shows that the insurance groups have a substantial amount of businesses besides the core insurance business. In aggregate, insurance subsidiaries account for about 50% of the total number of subsidiaries, followed by non-financial subsidiaries (40%) and other financial businesses (10%). The share of insurance subsidiaries is slightly lower in advanced economies, and it is more prominent in emerging markets and offshore centers. This data suggests that the insurance groups expand to emerging markets primarily for the purpose of doing insurance business. Also, the data indicates that the offshore subsidiaries are used primarily for facilitating the insurance and reinsurance business of the major insurance groups.

Next, we present the results for the major insurance markets. Figure 8 depicts the compo-

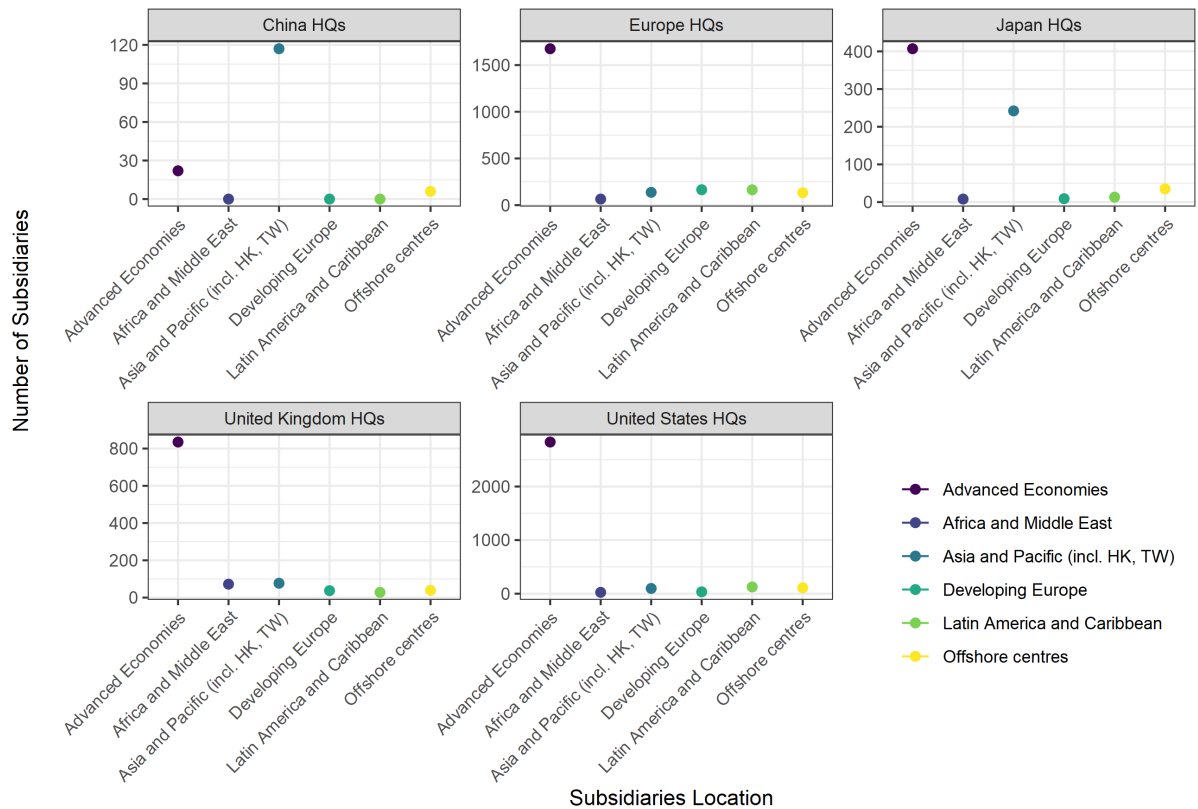


Figure 6: *Location Matrix for Advanced and Emerging Economies and Offshore Centers.*

This figure shows the location matrix of insurance groups in major insurance markets, revealing that most subsidiaries are in advanced economies. The figure offers valuable insights into the distribution of subsidiaries and the use of offshore centers, indicating the international operations and risk-sharing capabilities of global insurance groups.

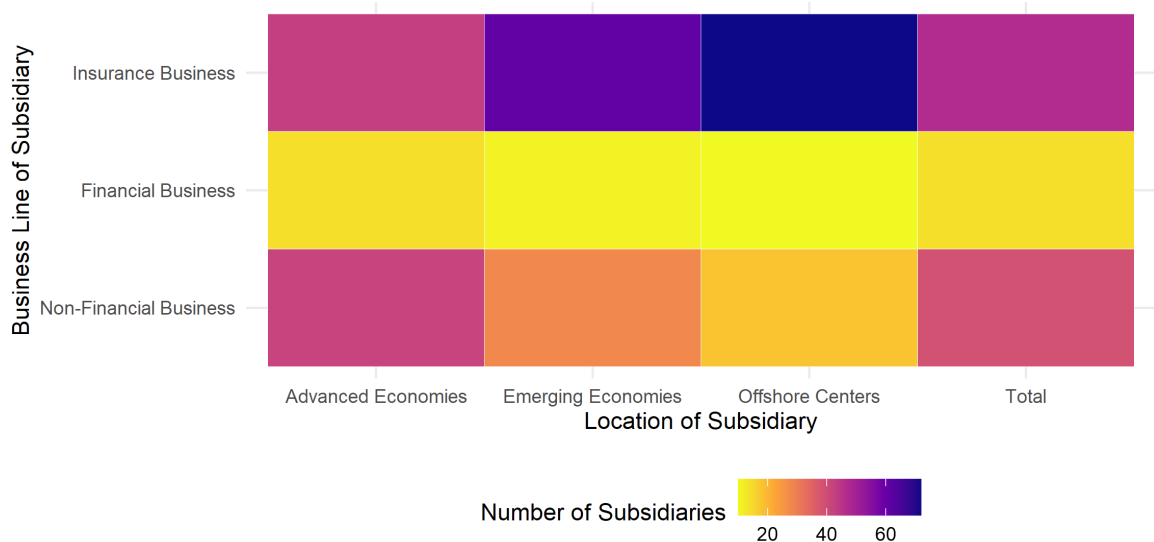


Figure 7: *Business Area of Subsidiaries by Location.*

This figure is a heatmap showing the business area of subsidiaries by location (advanced and emerging economies and offshore centers). The heatmap highlights the business diversity within insurance groups and the strategic significance of different geographic locations for their operations.

sition of the subsidiaries' business focus for the UK-headquartered insurance groups and distinguishes between the domestic and international subsidiaries. Domestically, the UK insurance groups have a significant share of reinsurance, financial and non-financial subsidiaries. Internationally, their subsidiaries are in insurance brokerage and non-financial businesses. Overall, the business focus of the subsidiaries of the UK insurance groups is in insurance brokerage and reinsurance rather than the primary insurance business in life and non-life insurance. The UK insurance groups also have a substantial number of non-insurance subsidiaries in both financial and non-financial sectors. These results suggest that the UK insurance groups are focused on the primary insurance business domestically but operate reinsurance and insurance brokerage businesses internationally.

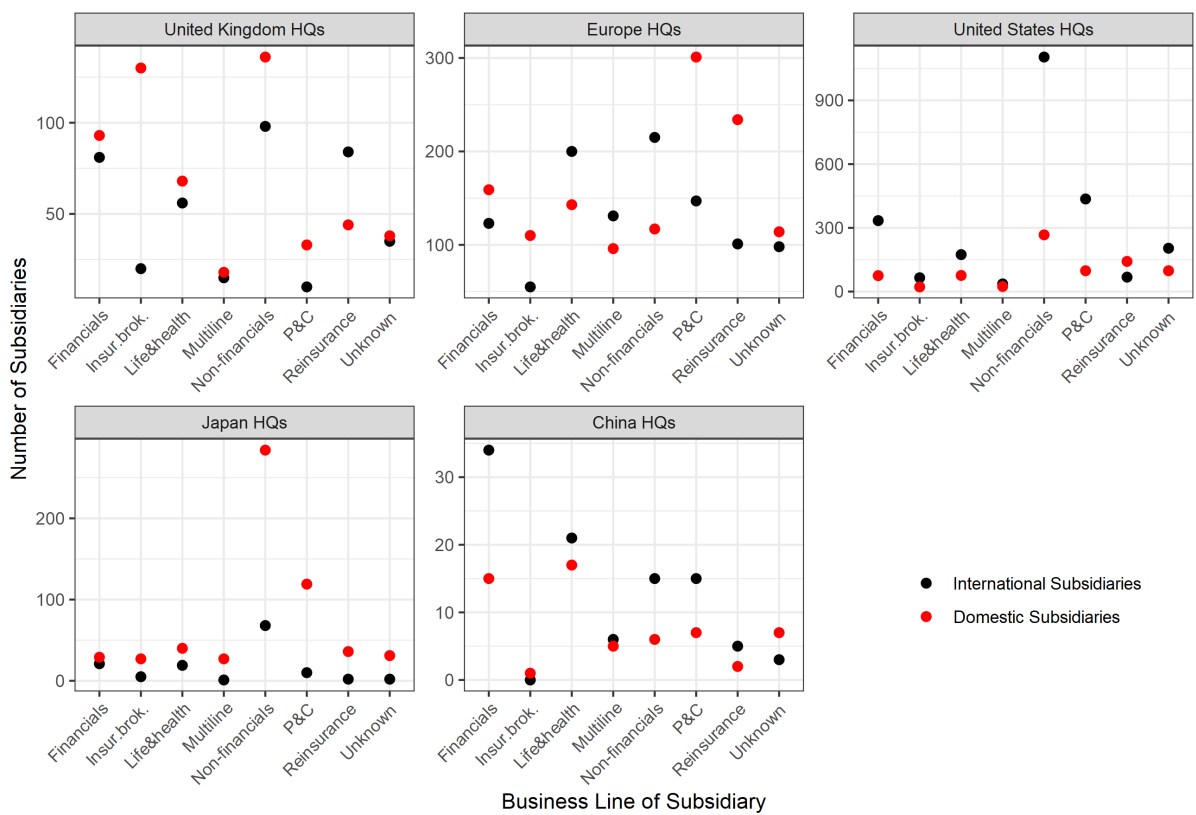


Figure 8: *Subsidiaries Business Lines*

This figure presents the business focus of subsidiaries for UK, European, US, Chinese, and Japanese insurance groups, both domestically and internationally. This figure reveals the diverse strategic orientations of insurance groups in major markets. The figure provides valuable insights into the business profiles and international strategies of insurance groups across different markets.

These results contrast with the structure of the European headquartered insurance groups. Unlike their UK peers, the European insurers expand to foreign markets with the primary insurance business. As an illustration of the scope of primary insurance business abroad, a Swiss HQ group Zurich AG, one of the largest global insurers, has 45% of its non-life portfolio business in auto policies in the US market. Figure 8 provides the details on the business focus of European insurance groups. It shows that the primary focus of

subsidiaries of the European insurance groups is indeed in non-life insurance and reinsurance market segments. Overall the business profile of the European insurance groups is rather balanced both domestically and internationally. Their domestic operations are more tilted to life and health insurance and nonfinancial subsidiaries. The international focus is on non-life insurance and reinsurance. The share of non-core insurance business in either financial or non-financial segments is less pronounced compared to the UK groups, both domestically and internationally.

The US groups, unlike the European peers, have a distinct number of non-financial subsidiaries in their group structure. As Figure 8 illustrates, non-financial subsidiaries account for more than 40% of the domestic subsidiaries and more than 30% of international subsidiaries. One distinct group in terms of the diverse mix of insurance and non-insurance businesses is the Berkshire Hathaway, the Warren Buffet conglomerate. Figure 8 also shows that the reinsurance subsidiaries of the US insurance groups are often located abroad. In part driven by regulation, Bermuda is the common location for the reinsurance subsidiaries of the US groups.

The business profile of the Chinese insurance groups indicates that they emerge as providers of a range of financial services in addition to insurance. Figure 8 shows that Chinese insurance groups have a high share of subsidiaries in life insurance and financial services. The share of life insurance is more pronounced than the share of non-life, and it is also the main focus of the Chinese insurance groups' foreign subsidiaries. One interesting finding is that the share of reinsurance subsidiaries is surprisingly small.

Finally, the business focus of the Japanese insurance groups depicted in Figure 8 reveals a strong presence of the non-financial subsidiaries in Japanese insurance groups, both domestically and abroad. The share of the non-financial subsidiaries is the highest for the Japanese insurance groups, which sets them distinct from the groups in the other major market. In terms of the primary insurance business, most domestic subsidiaries of Japanese groups are in life insurance, while their foreign subsidiaries are in the non-life insurance business. The domestic life insurance business is also complemented by a significant share of other financial services.

Overall, the data demonstrates that there is substantial diversity in business models in mature insurance markets. European insurance groups are primarily focused on the core life and non-life insurance business, both domestically and internationally. As for the UK groups, their expertise has been traditionally in reinsurance and insurance intermediation. The US and Japanese insurance groups usually have a high share of non-insurance subsidiaries, making them comparable to diverse conglomerates with a mix of different businesses under the same HQ holding company. The Chinese groups appear as broader

financial service providers with a high share of savings and pension-purpose life insurance products.

5 Measures of Complexity and Their Relation to Group Size

The complexity of an insurance group has multiple dimensions. We use several metrics which aim to capture different aspects of the group structure. The total number of subsidiaries, the number of levels in the corporate tree of a group, and the variety of activities across businesses and locations are all relevant features of the group complexity. Often the complexity of a financial institution is associated with its size, particularly in the context of too-big-to-fail (TBTF) debates.

To quantify the groups' geographic and business complexity, we use the indices which measure the dispersion of the group's subsidiaries across the categories. Our approach follows Cetorelli and Goldberg (2014), who analyze the geographic and business focus dimensions for banking groups operating in the US. Then we also evaluate the relationship between the complexity and size of the insurance group. We compare the significance of the complexity/size for banks and insurers.

The index of geographic complexity of a group j , GC_j , is a Herfindahl index based on subsidiary regions R defined in Table A.1, Panel B. It is calculated as:

$$GC_j = \frac{R}{R-1} \left(1 - \sum_{r=1}^R \left(\frac{\text{count}_j^i}{\text{totalcount}_j} \right)^2 \right), \quad (1)$$

where R is the total number of regions ($R = 9$), totalcount_j is the total number of subsidiaries of the insurance group j and count_j^i is the number of subsidiaries of group j in region i . GC index values range from 0 to 1, where 0 is the lowest complexity and 1 is the highest complexity.

Figure 9 presents the result for insurance groups from a selected number of countries. The top and the bottom whiskers identify the region's maximum and minimum level of geographic complexity, the box is the range between 25 to 75 quantiles, and the line inside the box is the median value. The index values are in line with the qualitative observations in the previous section. The GC index shows the highest level of geographic complexity for the Swiss (CH), EU, and UK insurance groups and the lowest level of complexity for Japan and US insurance groups, with Chinese groups laying in the middle of the range.

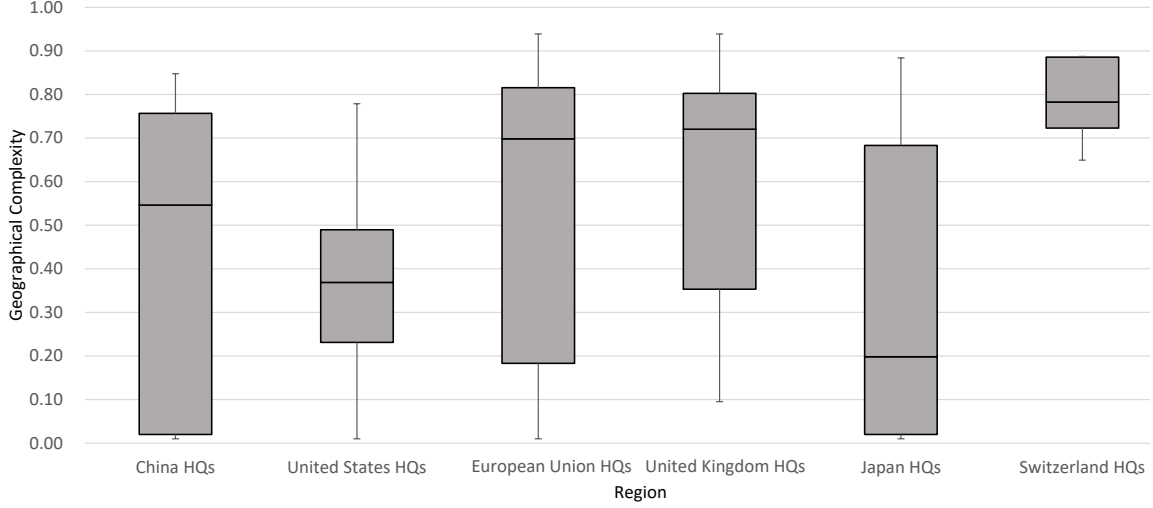


Figure 9: *Geographic Complexity by HQ Region.*

This figure presents the geographic complexity (GC) index for insurance groups from selected countries. The index values are based on qualitative observations mentioned in the previous section. The GC index ranges between 0 and 1. The highest level of geographic complexity is seen in the Swiss (CH), EU, and UK insurance groups, while the Japan and US insurance groups exhibit the lowest level of complexity. Chinese groups fall in the middle of the range. The box-and-whisker plot displays the range of values, with the top and bottom whiskers indicating the maximum and minimum complexity levels, respectively, and the box representing the range between the 25th and 75th quantiles, with the line inside the box representing the median value. The figure offers insights into the geographic complexity of insurance groups from different countries, providing valuable information on their international presence and expansion strategies.

Similarly, we calculate the index for the business complexity of insurance groups. The index of business complexity BC is based on subsidiaries types defined in Table 1. It is defined as:

$$BC_j = \frac{T}{T-1} \left(1 - \sum_{i=1}^T \left(\frac{\text{count}_j^i}{\text{totalcount}_j} \right)^2 \right), \quad (2)$$

where T is the number of types ($T = 4$), totalcount_j is the total number of subsidiaries in the insurance group j and count_j^i is the number of subsidiaries in type of business i for the insurance group j . Index values range from 0 to 1, where 0 is the lowest complexity and 1 is the highest complexity.

The results presented in Figure 10 show that the insurance groups in the US and Japan have relatively high levels and variations in business complexity. By contrast, the UK, EU, and Swiss insurance groups have relatively comparable and low levels and variations of business complexity.

Next, we evaluate the relationship between the insurance group's complexity and its size. A simple way to assess it is to consider the predictability of complexity measures by size.

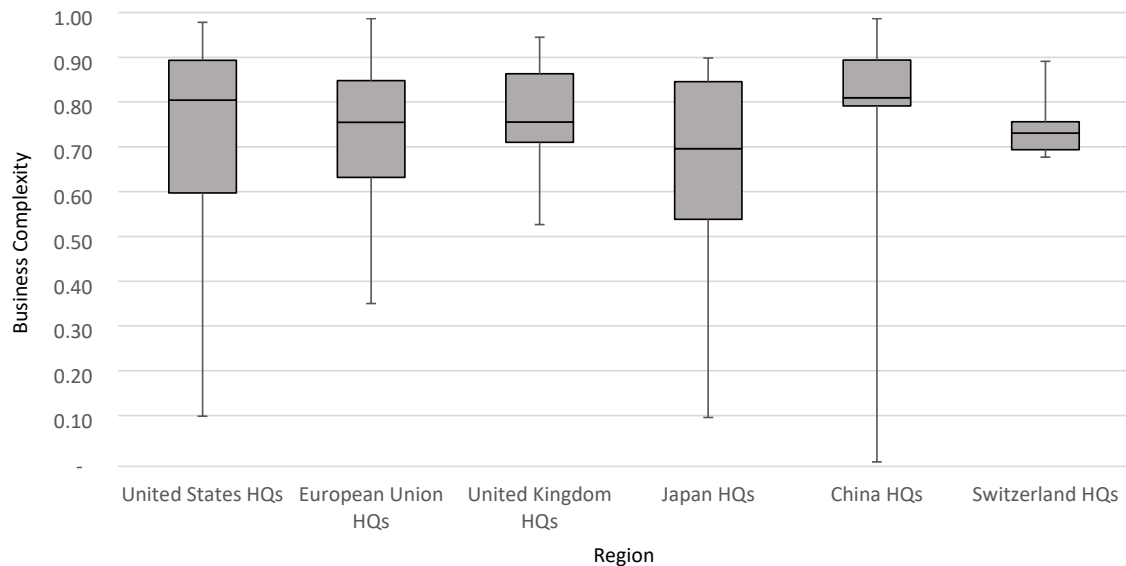


Figure 10: *Business Complexity by HQ Region.*

This figure illustrates the results for business complexity (BC) among insurance groups in different countries. The BC index ranges between 0 and 1. The box-and-whisker plot displays the range of values, with the top and bottom whiskers indicating the maximum and minimum complexity levels, respectively, and the box representing the range between the 25th and 75th quantiles, with the line inside the box representing the median value. The figure provides valuable insights into the variations in business complexity among insurance groups based on their headquarters countries, offering a comparative analysis of their strategic orientations.

Figure 11 shows a set of four regressions. In addition to the business and geographic complexity measures presented in this section (bottom two panels), we also perform the test using a simple count of subsidiaries and the ratio of insurance to non-insurance subsidiaries (top two panels). Two findings emerge. Consistent with TBTF discussions, the relationship between size and complexity is positive and significant. That is, groups with bigger sizes tend to have a more complex corporate structure. However, the low level of R^2 in all four regressions indicates that the size alone is a poor predictor of complexity.

A relevant benchmark to compare the relationship between size and complexity in insurance is its counterpart in banking. In Table 3 we present the comparison of the regression results for the indices of geographic and business complexity for insurers and banks using the results for the banking groups obtained in Cetorelli and Goldberg (2014).¹¹ We find that the relationship between size and complexity is weaker for insurers than for banks. For all measures of complexity discussed above, i.e. total count of subsidiaries, the share of non-insurance to insurance subsidiaries, and the business and geographic complexity indices, the ability of size to predict complexity measured by R^2 is much higher for banks than for insurers. The comparison suggests that the analysis of group complexity separately from group size is even more relevant for insurance groups than for banking

¹¹ We thank Nicola Cetorelli for sharing the indices of bank complexity derived in their analyses in Cetorelli and Goldberg (2014).

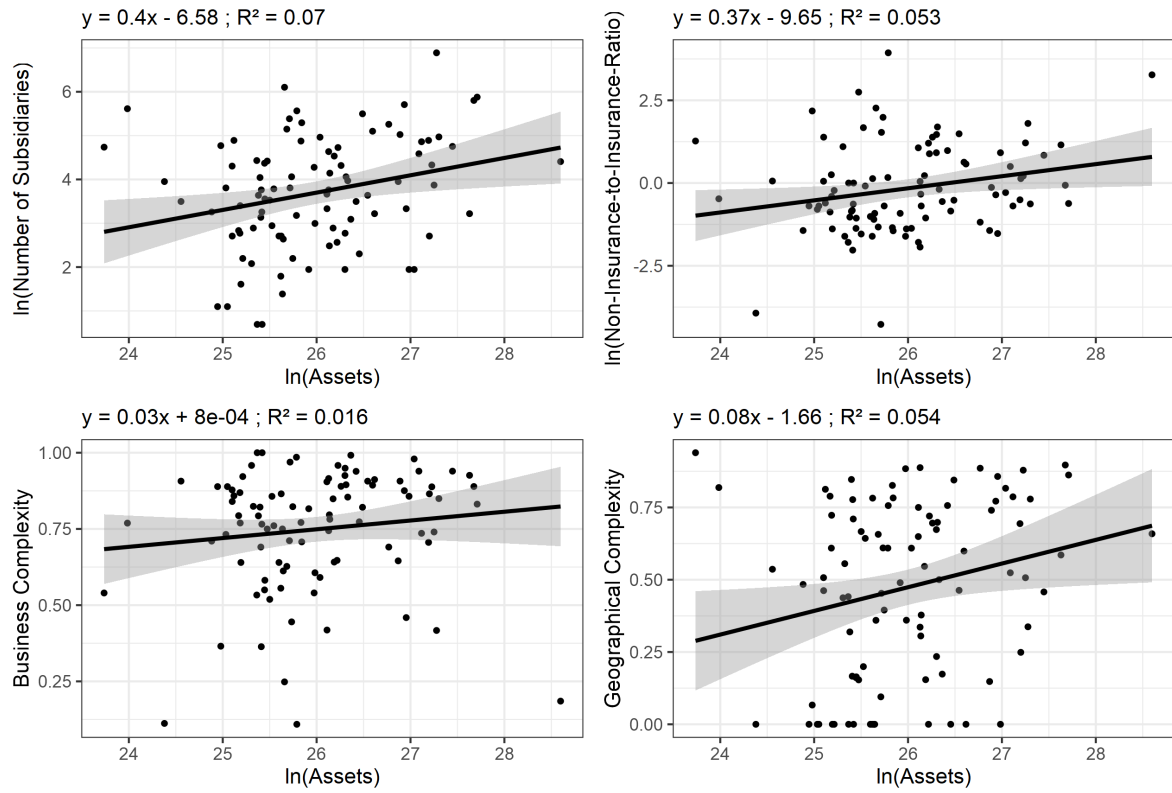


Figure 11: *Relationship Between Insurance Group Complexity and Its Size.*

This figure presents the estimated OLS coefficients and R^2 values for the four regressions. The complexity measures include business and geographic complexity, as well as a simple count of subsidiaries and the ratio of insurance to non-insurance subsidiaries. The positive and significant OLS coefficients indicate a positive relationship between size and complexity. The R^2 values are relatively low.

groups.

Measure	Banks	Insurers
$\ln(\text{Number of Subsidiaries})$ vs $\ln(\text{Assets})$	0.786	0.070
Non-Bank-to-Bank-Ratio vs $\ln(\text{Assets})$	0.172	-
Non-Insurance-to-Insurance-Ratio vs $\ln(\text{Assets})$	-	0.053
Business complexity vs $\ln(\text{Assets})$	0.016	0.016
Geographical complexity vs $\ln(\text{Assets})$	0.226	0.054

Table 3: *Size and Complexity in Insurance and Banking, R^2 .*

This table presents a comparison of regression results for the indices of geographic and business complexity in insurers and banks based on the findings from Cetorelli and Goldberg (2014). We acknowledge Nicola Cetorelli for sharing the bank complexity indices from their analysis in Cetorelli and Goldberg (2014). The table reveals that the relationship between size and complexity is notably weaker for insurers compared to banks. For all complexity measures examined, such as the total count of subsidiaries, the ratio of non-insurance to insurance subsidiaries, as well as the business and geographic complexity indices, the predictive power of size (as measured by R^2) is significantly higher for banks than for insurers.

6 Group Structure and Performance

In this section, we assess the relationship between insurance group complexity and its performance. To provide the preliminary tests of the effect of insurance group structure on its performance, we regress the common characteristics of market performances, Tobin Q, and return on assets (ROA) on the measures of the group structure discussed in the previous sections, including geographic and business complexity, the number of insurance subsidiaries, the share of non-insurance and financial subsidiaries and the group size (total assets). Such analysis requires market valuations and hence is feasible only for the insurance groups that are publicly traded. In our sample of 100 insurance groups, this applies to 62 groups. The other third of the groups in the sample are either mutual insurance companies or privately held companies.

The results of the analysis are reported in Table 4. Panel A reports the estimation of several regression specifications of the relationship between Tobin's Q and the insurance group's characteristics. In column (1), we include all group characteristics, that is, the group size (log of groups' total assets), the total count of insurance subsidiaries, the share of non-core business, including the non-insurance business and financial business as well as the measures of business and geographic complexity. In columns (2) to (5), we isolate different characteristics of the group structure to assess their individual contribution to the relationship between structure and performance. In column (6), we add the standard controls for the macroeconomic environment in the country of the insurance group HQ location, the long-term and short-term interest rates, and the GDP growth.

Across all specifications that include the measure of business complexity, we find that it

is positively related to the valuation of insurance groups. By contrast, it appears that the geographic complexity does not explain the groups' Tobin's Q. In all specifications, the estimated coefficients of the geographic complexity explanatory variable are not statistically significant and close to zero. As for the other characteristics of the insurance group structure, the larger total number of subsidiaries and the share of non-insurance business are positively related to the insurance group's Tobin's Q. However, the significant coefficient obtains only in one specification (6). We also find that the share of a financial business or the share of a non-insurance business in the insurance group does not explain performance in our regression specifications. While the non-insurance business share is positive and statistically significant (though not economically large) in the specification (2) that tests the relationship between the shares of insurance, non-insurance and financial businesses, and Tobin's Q, the significance is lost when the share of non-insurance business is combined with our business complexity index. As for the group size, we do not find a significant relationship with Tobin's Q.

We also use returns on assets (ROA) as an alternative measure of group performance. The results are presented in Table 4 Panel B. Similar to the analysis of Tobin's Q, we consider six distinct specifications to be able to distinguish the effect of different aspects of the insurers' business model on the ROA of the insurance group.

We find that ROA is positively related to the group's business complexity across all specifications. At the same time, ROA is not significantly affected by the insurance group's geographic complexity. These results are consistent with the findings when performance is measured by Tobin's Q, suggesting that the business complexity rather than the geographic complexity affects the group performance. We also find that ROA is positively related to the total number of subsidiaries in the group. As for the total size of the group, it has a negative effect on its ROA, though the results are not significant across all specifications, and in terms of the economic significance, the coefficients are close to zero.

To put our findings in perspective, corporate finance theory has identified several mechanisms by which complexity (positively or negatively) affects performance, as discussed in Section 2. In an influential paper, Leaven and Levine (2007) find that banks that perform diverse activities, i.e., lending and no-lending financial services, experience a diversification discount. That is, the market valuations of financial conglomerates with multiple activities are lower than if those businesses operated the activities on a stand-alone basis. Leaven and Levine (2007) argue that the result is consistent with theories that point to the agency problems created by engaging in multiple activities and suggest that the economies of scope are not sufficient to produce a diversification premium.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Tobin's Q						
Intercept	0.973*** (0.0586)	1.027*** (0.0506)	0.954*** (0.0554)	0.975*** (0.0541)	0.982*** (0.0504)	0.922*** (0.0514)
Total Assets (log)	- 0.00110 (0.00981)	- 0.00135 (0.00930)	0.00479 (0.00905)	0.00226 (0.00913)	0.00257 (0.00890)	- 0.00425 (0.00819)
# subsidiaries / 100	0.0103 (0.00699)					0.0153*** (0.00563)
Non-insurance business	2.99e- 05 (0.00165)	0.00243* (0.00132)		0.000120 (0.00163)		0.000506 (0.00138)
Financial business	0.00868 (0.0108)	- 0.00217 (0.00953)		0.00914 (0.0105)		0.0129 (0.00895)
Business complexity	0.121** (0.0586)		0.125*** (0.0441)	0.133** (0.0586)	0.124*** (0.0442)	0.148*** (0.0523)
Geographic complexity	0.0354 (0.0372)		0.0433 (0.0359)			0.0320 (0.0361)
Long Term Interest Rate						- 0.00132 (0.0163)
Short Term Interest Rates						0.00301 (0.0164)
GDP growth (% Annual)						0.0185* (0.0106)
Observations	62	62	62	62	62	62
R^2	0.183	0.057	0.140	0.135	0.118	0.118

	(1)	(2)	(3)	(4)	(5)	(6)
Panel B: Return on Assets (ROA)						
Intercepts	1.673** (0.678)	2.119*** (0.646)	1.246* (0.701)	1.349* (0.680)	1.482** (0.634)	1.558** (0.759)
Total Assets (log)	- 0.288** (0.114)	- 0.216* (0.119)	-0.166 (0.115)	-0.163 (0.115)	-0.184 (0.112)	- 0.324** (0.121)
# subsidiaries / 100	0.289*** (0.0809)					0.337*** (0.0833)
Non-insurance business	- 0.0257 (0.0191)	0.0147 (0.0169)		- 0.0191 (0.0205)		- 0.0255 (0.0204)
Financial business	0.0266 (0.125)	-0.175 (0.121)		- 0.00991 (0.131)		0.0545 (0.132)
Business Complexity	1.731** (0.678)		1.612*** (0.558)	1.948** (0.736)	1.609*** (0.557)	1.890** (0.774)
Geography Complexity	0.325 (0.431)		0.364 (0.455)			0.211 (0.533)
Long Term Interest Rates						-0.227 (0.241)
Short Term Interest Rates						0.266 (0.242)
GDP growth (% Annual)						0.120 (0.156)
Observations	62	62	62	62	62	62
R^2	0.348	0.086	0.177	0.186	0.168	0.463

Table 4: *Group Structure and Performance*

This table analyses the relationship between insurance groups' complexity measures and performance measures of an insurance group. In particular, the table has two dependent variables Tobin's Q in Panel A and Return of Assets (ROA) in Panel B. The sample consists of 62 publicly traded global insurance groups. Tobin's q and Total assets (in USD bn) are the averages of reported values for all quarters available from the end of 2016 to the end of 2017 in Bloomberg. Non-insurance business is the ratio of the number of non-insurance to insurance subsidiaries in a group. Financial business is the ratio of non-insurance financial subsidiaries to insurance subsidiaries. Business complexity and geographic complexity are the Herfindahl indices of complexity. Standard errors are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels.

Our analysis indicates that the balance turns in favor of diversification across business activities for insurance companies. As suggested by estimation results in Table 4, across all specifications and for two measures of performance, Tobin’s Q and ROA, the insurance group performance is positively related to its business complexity. However, further research is necessary to explore the exact mechanism of how the value is created by diversification between insurance and non-insurance businesses.

7 Complexity and Global Risk Sharing

Higher group complexity can bring the benefits of diversification and deepen the internal capital market of the insurance group, which enables insurance groups to enter less developed and more risky insurance markets with larger insurance protection gaps. However, complexity can also be a response to alleviate the regulatory barriers and capital controls. Relatedly, it can be motivated by regulatory arbitrage between various domestic insurance regulatory regimes. In this section, we present some preliminary findings that explore the relationship between the insurance group complexity and global risk sharing, focusing on the domestic macroeconomic and regulatory factors that affect insurance groups’ incentives to set up foreign subsidiaries.

As a starting point, using the data on the location and business focus of about 8,000 subsidiaries of the major insurance groups in our sample, we estimate how the aggregate number of subsidiaries of the major groups in a particular country depends on its macroeconomic environment and domestic insurance market characteristics. We use the total number of subsidiaries in a country by the major insurance groups is a proxy for the appeal of a country’s insurance market for international insurance groups. As explanatory variables, we include standard macroeconomic indicators such as the country’s GDP growth, GDP per capita, sovereign credit rating, capital controls, and the financial development index. The macroeconomic variables are obtained from the World Bank and the IMF.¹² For the characteristics of its insurance market, we consider insurance density, insurance penetration, the share of foreign insurers in the domestic insurance market as well as the insurance regulatory regime. The insurance market density and penetration and the share of foreign insurers in the market are obtained from the OECD insurance statistics database.¹³

Insurance regulatory regimes vary significantly even among the major insurance markets,

¹² The country GDP growth and GDP per capita is available at <https://data.worldbank.org/>. The IMF financial development index is available at <https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B>

¹³ OECD insurance statistics database is available at <https://stats.oecd.org/Index.aspx?DatasetCode=INSIND>

with an even higher degree of diversity globally. We construct a simple index for the regulatory regime for the complete sample of 117 countries using the characteristics of regulatory regimes across countries reported by national supervisors, the International Association of Insurance Supervisors, and the International Monetary Fund assessments. Our ranking is based on criteria specified below in Table 5.

Supervisory regime	Rank	Definition
No requirements	1	No framework
Minimum capital	2	The supervisor requires minimum capital to establish and operate an insurance company
Size-based Formula, no risk weight	3	The supervisor uses a formula aggregating assets and liabilities to establish capital requirements, but there are no risk weights
Risk-based capital	4	The supervisor uses a risk-based assessment of capital needs
Economic capital US	5	US and Canada style - The capital requirement is based on a comprehensive risk-based assessment of the balance sheet and includes stress-test-based capital requirements
Economic capital SII	6	Solvency II style - The capital requirement is based on a comprehensive risk-based assessment of the balance sheet and includes stress-test-based capital requirements

Table 5: Supervisory Regimes Classifications.

The table provides classifications of supervisory regimes based on a simple index constructed for the complete sample of 117 countries. The index is created using characteristics of regulatory regimes reported by national supervisors, the International Association of Insurance Supervisors, and the International Monetary Fund assessments. The ranking is based on specific criteria, as outlined in Table 1. The supervisory regimes are categorized into six ranks, ranging from "No requirements" (Rank 1) to "Economic capital SII" (Rank 6) based on the level of regulatory requirements and risk-based assessment of capital needs. These classifications offer insights into the significant variations in insurance regulatory frameworks across different countries and regions.

In Table 6, we report the estimation results of three specifications, (1) the total number of insurance subsidiaries, (2) the subsidiaries in the life sector, and (3) subsidiaries in the non-life sector. To account for possible non-linearities of the relationships between the decision to enter a given market and the country's credit rating and the regulatory regime, we consider a quadratic specification for these variables. The results show that the IMF financial development index is one of the key determinants of the insurance group setting a subsidiary in a given country. The country's credit rating is marginally significant, and the relationship is non-linear for non-life insurance. Countries with higher ratings are more attractive to insurance groups to set up their subsidiaries but at a decreasing marginal rate. The regulatory regime variables are not significant, though the coefficients have expected signs with a more developed risk-based regulatory regime attracting more foreign subsidiaries. Finally, insurance penetration (which is calculated as the ratio of total insurance premiums to gross domestic product) is a factor that affects where insurance groups set their foreign non-life insurance subsidiaries. As for the life insurance business, the country's GDP per capita is positively associated with the number

of foreign subsidiaries.

VARIABLES	Total subsidiaries (1)	Life insurance (2)	Non-life insurance (3)
GDP Growth (%)	-10.33 (20.24)	-0.613 (1.731)	-8.014 (17.49)
GDP Per Capita (Current USD)	0.00469 (0.00366)	0.000513* (0.000301)	0.00461 (0.00286)
Financial development index	936.2*** (351.8)	88.48*** (29.36)	602.6* (310.2)
Credit Rating	414.8 (283.2)	41.94* (24.31)	447.6* (246.9)
Credit Rating ²	-59.59 (46.69)	-5.988 (4.004)	-68.18* (40.82)
Regulatory Regime Rank	217.6 (286.7)	23.50 (24.57)	196.8 (247.9)
Regulatory Regime Rank ²	-31.66 (32.74)	-3.207 (2.805)	-30.51 (28.33)
Insurance Penetration - Total	1.018 (11.41)		
Insurance Penetration - Life		-0.582 (0.945)	
Insurance Penetration - Non-Life			65.95** (25.25)
Constant	-1,363* (768.9)	-140.5** (65.72)	-1,291* (662.4)
Observations	79	79	79
R ²	0.189	0.226	0.257

Table 6: *Domestic Insurance Market and Insurance Groups Entry.*

The table analyzes the relationship between the characteristics of the domestic insurance markets and a number of insurance subsidiaries. Furthermore, the table makes a distinction between three dependent variables: the total number of insurance subsidiaries, the number of life insurance subsidiaries, and the non-life insurance subsidiaries of the major insurance groups. The Financial Development Index is the IMF index value in 2017. The credit rating is the sovereign credit rating by Moody's aggregated into 5 categories, with a higher category referring to a higher rating. Regulatory regime rank is the domestic regulatory regime rank constructed as reported in Table 5. Insurance penetration is the ratio of insurance premiums to GDP in 2017. Standard errors are in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% level.

One of the features of the global insurance groups is a high number of offshore subsidiaries. To explore the motivation for the insurance group to set up subsidiaries in the offshore financial centers and the relationship between the insurance group business and geographic complexity and offshore operations, we estimate how the number of offshore subsidiaries in a group as well as their share in the total number of subsidiaries are related to the possible motives of setting up these subsidiaries. Our set of explanatory variables includes the number of regulatory regimes in which the group is operating as well as the average regulatory regime and the diversity of regulatory regimes of the group's subsidiaries (calculated as the standard deviation of the regulatory regimes of group subsidiaries). In addition, we include the measure of Capital Control as reported by IMF. We also include the measures of group business and geographic complexity.

The results are reported in Table 7. We estimate that the total number of offshore subsidiaries in an insurance group is positively related to the number of regulatory regimes in which the insurance group is operating. Also, it is negatively related to the diversity of regulatory regimes. Insurance groups are also more likely to set up offshore subsidiaries if they operate a larger number of subsidiaries in countries with high capital controls. At the same time, business complexity does not affect the number of offshore subsidiaries, while the relationship between the number of offshore subsidiaries and geographic complexity is negative.

VARIABLES	Number of Offshore Subsidiaries (1)	Share of Offshore Subsidiaries (2)
Number of Regulatory Regime	1.651*** (0.579)	-0.00178 (0.0111)
Diversity of Regulatory Regime	-3.942** (1.972)	0.0455 (0.0378)
Average of Regulatory Regime	-0.893 (0.892)	-0.0832*** (0.0171)
Total Number of Subsidiaries	0.0164*** (0.00367)	-0.000169** (7.05e-05)
No. of Subsidiaries in High Capital Control	0.196* (0.116)	0.00463** (0.00223)
Business Complexity	-1.459 (1.699)	0.00399 (0.0326)
Geographical Complexity	-6.158*** (2.163)	-0.0349 (0.0415)
Constant	8.196 (5.749)	0.498*** (0.110)
Observations	100	100
R^2	0.664	0.426

Table 7: *Offshore Subsidiaries and Regulatory and Capital Control Regimes.*

The table reports the regression results to analyze the relationship between the number and share of offshore subsidiaries and the regulatory regime and capital control characteristics, as well as the insurance group complexity. The number of regulatory regimes measures the total number of regulatory regimes in which the group is operating; the diversity of regulatory regimes is the standard deviation of the regulatory regimes of the group subsidiaries, and the average regulatory regime is the mean regulatory regime. A high capital control country is a country with a capital control index equal to 3. Business complexity and geographic complexity are the Herfindahl indices of complexity. Standard errors are in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% level.

Interestingly, the share of offshore subsidiaries in the insurance group is lower for groups operating in countries with higher average regulatory regimes. However, it is higher for groups with a larger number of subsidiaries in high capital control countries.

8 Complexity and Protection Gap

The protection gap is the difference between full insurance coverage and the coverage that is actually in place. The protection gap is one of the greatest issues today. Swiss Re (2019), p. 1, estimates the total protection gap to be equivalent to USD 1.2 trillion in premium terms in 2018 in total across three perils: health, natural catastrophes and mortality risk. Figure 12 depicts that the protection gap has doubled since the year 2000. The main reasons for this change are the climate change and the aging population. As former results from Section 6 show, the group complexity is positively related to the performance of insurance groups. We aim to assess in this section whether this performance translates from the insurance groups seizing this opportunity through their expansion strategy.

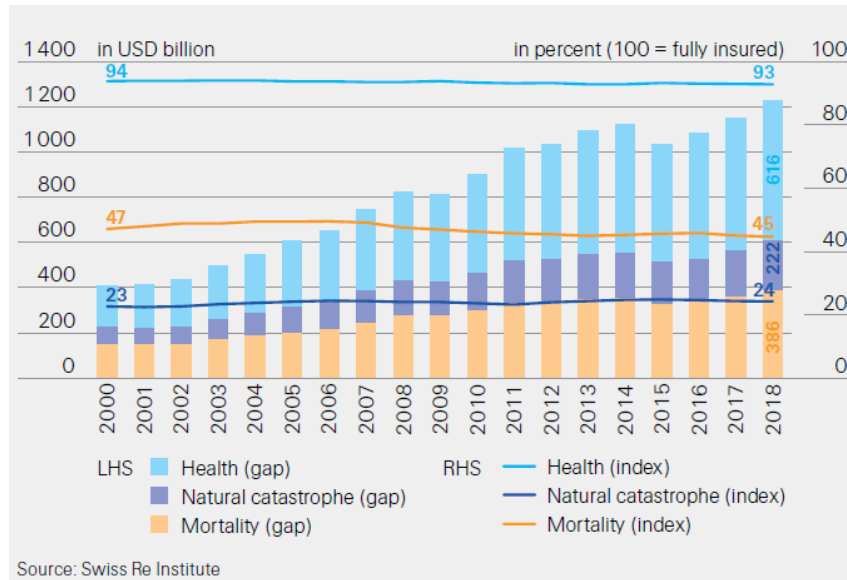


Figure 12: *Protection Gap and Resilience Index Change Over Time.*

This figure depicts the change in the protection gap and resilience index across three perils: health, natural catastrophe, and mortality from 2000 until 2018. The bars correspond to the protection gap perils, whereas the lines correspond to the resilience index perils. The source for the figure is Swiss Re (2019), p. 27.

In the next set of results, we assess whether the insurance groups' structure aids in resolving the protection gap. Specifically, we estimate the relationship between insurance groups' geographical and business complexity and the protection gap. Additionally, we extend our analysis using an alternative set of dependent variables, such as the resilience index and total risk exposure for each country. This extension helps in identifying more precisely the expansion strategy of insurance groups across different countries. We control the regression specifications with two firm-specific market variables - the market share of foreign subsidiaries and the index of the dominance of insurance groups to enhance heterogeneity analysis among insurance groups. We also control for the gross premiums

at the country level and for the number of subsidiaries at the group level across all specifications.

First, we introduce the variable that stands for the foreign market share of subsidiaries of an insurance group in each country. Using the data from the OECD for 57 countries, we estimate the average market share of foreign insurance subsidiaries for life and non-life insurance, representing the share held by all groups in that country. The derivation is as follows:

$$M_j = \frac{1}{n} \sum_{i=1}^n M_{ij}$$

M_{ij} indicates the market share for a segment in country j , averaged over the segments i available (life and non-life).

Furthermore, we also estimate the share of subsidiaries established by group i in the country j using the previous data on the hierarchical structure of insurance groups as follows:

$$P_{ij} = \frac{N_{ij}}{\sum_i N_{ij}},$$

where P_{ij} represents the percentage of subsidiaries for group i in the country j , calculated from the total subsidiaries in the country j .

Finally, we derive the real market share percentage held by insurance group i in a country j by multiplying both former measures as follows:

$$A_{ij} = P_{ij} \times M_j,$$

where M_j denotes the average market share of foreign subsidiaries, in percentages for country j , and P_{ij} represents the percentage of foreign subsidiaries for group i in the country j .

The second measure we use is the index of dominance derived for all insurance groups. The index of dominance represents the normalized sum of market shares that each group holds across different countries. We construct it as follows:

$$\text{Index of Dominance}_i = \frac{\sum_j A_{ij} - \min(\sum_j A_{ij})}{\max(\sum_j A_{ij}) - \min(\sum_j A_{ij})},$$

where A_{ij} is the percentage of the market share held by group i in country j . The sum $\sum_j A_{ij}$ represents the total market share held by group i across all countries. The normalization scales the sum by subtracting the minimum sum across all groups and dividing by the range of sums across all groups. This normalization ensures the index values are scaled between 0 and 1.

We obtain the protection gap and resilience index data for 57 countries from Swiss Re. For the following analysis, we normalize the protection gap in each country using GDP. We also gather GDP data for each country from the OECD. We derive the measure of risk exposure using these data sources for each country as follows:

$$\text{Risk Exposure} = \frac{\text{Total Protection Gap}}{(1 - \text{Resilience Index}) \times \text{GDP}},$$

The first regression specification to assess the impact of complexity measures on the normalized protection gap is as follows:

$$\begin{aligned} \text{Normalized Protection Gap} = & \beta_0 + \beta_1 \text{Market Share} + \beta_2 \text{FDI} + \\ & \beta_3 \text{Log}(\text{Gross Premiums}) + \beta_4 \text{Geographical Complexity} + \\ & \beta_5 \text{Business Complexity} + \\ & \beta_6 \text{Log}(\text{Total Number of Subsidiaries}) + \\ & \beta_7 \text{Index of Dominance} + \beta_8 (\text{Market Share} \times \text{FDI}) + \epsilon. \end{aligned}$$

In the next specification, we assess the impact of complexity measures on the resilience of countries to withstand losses as follows:

$$\begin{aligned} \text{Resilience Index} = & \beta_0 + \beta_1 \text{Market Share} + \beta_2 \text{FDI} + \\ & \beta_3 \text{Log}(\text{Gross Premiums}) + \beta_4 \text{Geographical Complexity} + \\ & \beta_5 \text{Business Complexity} + \\ & \beta_6 \text{Log}(\text{Total Number of Subsidiaries}) + \\ & \beta_7 \text{Index of Dominance} + \beta_8 (\text{Market Share} \times \text{FDI}) + \epsilon. \end{aligned}$$

Lastly, we estimate also the relationship between the risk exposure and insurance groups' complexity measure following:

$$\begin{aligned} \text{Risk Exposure} = & \beta_0 + \beta_1 \text{Market Share} + \beta_2 \text{FDI} + \\ & \beta_3 \text{Log}(\text{Gross Premiums}) + \beta_4 \text{Geographical Complexity} + \\ & \beta_5 \text{Business Complexity} + \\ & \beta_6 \text{Log}(\text{Total Number of Subsidiaries}) + \\ & \beta_7 \text{Index of Dominance} + \beta_8 (\text{Market Share} \times \text{FDI}) + \epsilon. \end{aligned}$$

The Tables 8, 9, and 10 depict the regression results for dependent variables of normalized protection gap, resilience index, and total exposure to risk across all countries.

Regarding the impact of groups' structure on protection gap resolution, the results show that geographical complexity has a significant negative effect as Tables 8 and 10 show, or non-significant effect as in the Table 9. The business complexity, on the other hand, has a significant positive effect with normalized protection gap and risk exposure, whereas the effect is negative in the regression for the resilience index. To conclude, the business complexity of insurance groups has a positive impact on protection gap resolution.

The results show that market share across all specifications has a significant positive relationship with normalized protection gap, exposure to risk, and negative relationship with resilience index. This finding indicates that insurance groups have a higher market share in markets or countries with higher risk exposure and protection gaps, whilst having a lower market share in countries with higher resilience indexes. This implies that in their expansion strategy, insurance groups target markets with higher demand for insurance or where there are unmet insurance needs.

Furthermore, the results show that the interaction term of market share and financial development index has a significant negative relationship with normalized protection gap and risk exposure and a negative relationship with the resilience index. This result suggests that insurance groups expand in developing countries, and more developed countries would have a lower presence of insurance groups in terms of market share even if they have a high protection gap, as the interaction moderates the main effect.

The index of dominance has non-significant coefficients in two of the three regression model specifications, being negatively significant only in the regression with the resilience index. This finding implies that insurance groups that dominate the markets across many countries typically do so in countries with lower insurance coverage.

Overall, the findings indicate that the group's structure partially plays a role in resolving the protection gap. On the one hand, the group's operational and functional diversification aids in resolving the protection gap problem, unlike its geographical complexity. On the other hand, they aim to take over a higher market share in developing countries. Furthermore, we identify that groups that aim to diversify in order to dominate the markets globally set up subsidiaries in countries with lower resilience to risk. The analysis suggests that insurance groups do not fully grasp the opportunity of commercializing the protection gap opportunity, with market competition being the main proponent in their expansion strategy.

	Normalized Protection Gap
Market Share	0.058*** (0.008)
Financial Development Index	0.014*** (0.001)
log(Gross Premiums)	0.0003*** (0.0001)
Geographical Complexity	-0.001*** (0.0003)
Business Complexity	0.002*** (0.0003)
log(Number of Subsidiaries)	-0.0001 (0.0001)
Index of Dominance	0.0003 (0.0005)
Market Share $\times$ Financial Development Index	-0.056*** (0.012)
Constant	-0.004*** (0.001)
Observations	6,782
R ²	0.066
Adjusted R ²	0.065
Residual Std. Error	0.006 (df = 6773)
F Statistic	60.042*** (df = 8; 6773)

Table 8: *Insurance Groups' Structure and Normalized Protection Gap.*

This table presents regression results examining the impact of insurance groups' geographic and business complexity on the normalized protection gap. The independent variables include market share, financial development index, gross premiums, geographic complexity, business complexity, number of subsidiaries, and index of dominance. The market share and index of dominance assist in outlining strategies for the expansion of insurance groups into other markets. The interaction between market share and the financial development index is also analyzed. The findings indicate that higher market share and business complexity are positively associated with the normalized protection gap, whereas geographic complexity shows a negative effect. The interaction term suggests that insurance groups tend to have lower market shares in more financially developed countries. Data for the protection gap is sourced from Swiss Re, while GDP data is obtained from the OECD. The market share variable relies on data that is sourced from the OECD and represents the market share of foreign insurance subsidiaries of an insurance group in each given country for life and non-life sectors. Standard errors are in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% level.

	Resilience Index
Market Share	−676.856*** (26.973)
Financial Development Index	64.197*** (2.271)
log(Gross Premiums)	−6.268*** (0.117)
Geographical Complexity	0.294 (0.558)
Business Complexity	−4.553*** (0.628)
log(Number of Subsidiaries)	0.236 (0.165)
Index of Dominance	−1.925** (0.825)
Market Share × Financial Development Index	932.686*** (37.362)
Constant	84.509*** (1.594)
Observations	6,763
R ²	0.427
Adjusted R ²	0.426
Residual Std. Error	10.481 (df = 6754)
F Statistic	629.286*** (df = 8; 6754)

Table 9: *Insurance Groups' Structure and Resilience Index.*

This table presents regression results analyzing the effects of insurance groups' geographic and business complexity on the resilience index of various countries. The independent variables include market share, financial development index, gross premiums, geographic complexity, business complexity, number of subsidiaries, and index of dominance. The market share and index of dominance variables help illustrate the strategic expansion of insurance groups into different markets. The interaction between market share and the financial development index is also assessed. The results show that higher market share and business complexity are negatively associated with the resilience index, while the financial development index and the interaction term between market share and financial development index show positive associations. Geographic complexity does not have a significant effect. Data for the resilience index is sourced from Swiss Re, while GDP data is obtained from the OECD. The market share variable relies on data that is sourced from the OECD and represents the market share of foreign insurance subsidiaries of an insurance group in each given country for life and non-life sectors. Standard errors are in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% level.

	Risk Exposure
Market Share	0.977*** (0.037)
Financial Development Index	0.069*** (0.003)
log(Gross Premiums)	−0.001*** (0.0001)
Geographical Complexity	−0.006*** (0.001)
Business Complexity	0.003*** (0.001)
log(Number of Subsidiaries)	−0.001*** (0.0002)
Index of Dominance	−0.0001 (0.001)
Market Share × Financial Development Index	−1.212*** (0.052)
Constant	−0.017*** (0.002)
Observations	5,446
R ²	0.169
Adjusted R ²	0.167
Residual Std. Error	0.011 (df = 5437)
F Statistic	137.837*** (df = 8; 5437)

Table 10: *Insurance Groups' Structure and Exposure to Risk.*

This table presents regression results evaluating the impact of insurance groups' geographic and business complexity on the risk exposure of various countries. The independent variables include market share, financial development index, gross premiums, geographic complexity, business complexity, number of subsidiaries, and index of dominance. The market share and index of dominance variables are utilized to describe the strategic expansion of insurance groups into different markets. The interaction between market share and the financial development index is also considered. The findings indicate that higher market share and business complexity are positively associated with risk exposure, while geographic complexity and number of subsidiaries have negative effects. The interaction term suggests that insurance groups tend to have lower market shares in more financially developed countries. Data for the protection gap and resilience index is sourced from Swiss Re, while GDP data is obtained from the OECD. The market share variable relies on data that is sourced from the OECD and represents the market share of foreign insurance subsidiaries of an insurance group in each given country for life and non-life sectors. Risk exposure is calculated by normalizing the protection gap with each country's resilience index and GDP, allowing for standardized comparison across different countries. Standard errors are in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% level.

9 Diversity of Insurance Business Lines

This section discusses the efficiency of capital transactions among insurance companies operating within the same business line. We look at the following eight insurance business lines: 'financial guaranty', 'insurance broker', 'life and health', 'managed care', 'mortgage guaranty', 'multiline', 'property and casualty', and 'reinsurance'. The insurance companies within these business lines employ reinsurance as a part of their risk management practices. The capital transfer or reinsurance within the same business line can foster

the use of expertise, assist insurance companies to meet capacity constraints, offer corresponding protection for risks that they would be unable to bear alone and to be able to reduce the concentration of risks on the balance sheet.

We focus on the approximation of reinsurance transactions at the level of business lines because there is a lack of a particular dataset at the granular level for the international capital transactions among insurance subsidiaries within a single insurance group. Nevertheless, one can draw a general conclusion about reinsurance efficiency among experts for each specific risk.

We obtain the data for the current section from the S&P Market Intelligence Capital IQ database for 296 insurance companies for 2017. For the following analysis, one needs access to much more granular data such as capital expenditure, price/earnings ratio, and market capitalization, which is available primarily for publicly traded insurance companies. Therefore, the sample shrinks from 29'318 insurance companies to only 296. Additionally, from 100 insurance groups, the sample reduces to only 50 groups for the paper's current section, which are present across 68 geographical locations internationally. Most groups in the sample are concentrated primarily in the US, which is one of twenty locations of HQs of these groups in the sample.

In order to approximate the efficiency of capital transactions, we employ the approach by Rajan et al. (2000). As most transfers from/to divisions are unobservable, one can approximate the transfers between companies by comparing the investment ratio of an insurance standalone company and when it is completely diversified. Effectively, this procedure implies subtracting the average investment ratio of insurance companies in a segment from each investment ratio of an insurance company. The positive sign indicates that the insurance company receives capital, whereas a negative sign of an adjusted investment ratio indicates that an insurance company invests the capital. In the following, to approximate the efficiency of each transfer, we weigh all adjusted investment ratios of insurance companies using our proxy for investment opportunities (Tobin's Q) and book value of assets. For example, if an insurance company makes a transfer in the 'right' direction, the company with the relatively highest Tobin's Q would receive the highest value added if the sign is positive. Alternatively, the outflow of capital from an insurance company with the best investment opportunities or highest Tobin's Q would result in a negative multiplier or destruction of value added by allocation. Therefore, our proxy for the efficiency of capital transactions is the absolute value added by allocation. One can obtain this measure as follows:

$$\text{Absolute Value Added by Allocation} = \frac{\sum_{j=1}^n BA_j (q_j - 1) \left(\frac{I_j}{BA_j} - \frac{I_j^l}{BA_j^l} \right)}{BA}, \quad (3)$$

where n represents the total number of insurance companies, j is an index variable for each insurance company. BA_j is the book value of assets. q_j represents Tobin's Q. I_j refers to the capital expenditures made by the insurance company. Furthermore, BA_j^l represents the average book value of assets for a specific business line l , and I_j^l refers to the average capital expenditures made by the insurance business line l .

Besides, we employ an additional measure of diversity, following the paper of Rajan et al. (2000), which measures the diversity of the opportunities of the insurance business line for potential capital allocations. We construct this measure as follows:

$$\text{Diversity} = \frac{\sqrt{\sum_{j=1}^n \frac{(w_j q_j - \overline{wq})^2}{n-1}}}{\frac{\sum_{j=1}^n q_j}{n}}, \quad (4)$$

where the numerator measures the standard deviation of the asset-weighted Tobin's Q for each business line, and the denominator measures the equally weighted Tobin's Q of each business line. w_j is the weight of each insurance company within each business line, and q_j represents Tobin's Q measure for each insurance company. $\overline{wq}$ denotes the average of the product of weights and Tobin's Q across all insurance companies in the business line.

In order to test the impact of diversity within insurance business lines on the efficiency of capital allocation, we establish the following three ordinary least squares models:

$$\begin{aligned} \text{Absolute Value Added by Allocation} &= \alpha + \beta_1 \times \text{Firm Size} \\ &+ \beta_3 \times \text{Diversity} + \epsilon \end{aligned} \quad (5)$$

$$\begin{aligned} \text{Absolute Value Added by Allocation} &= \alpha + \beta_1 \times \text{Firm Size} \\ &+ \beta_2 \times \text{Inverse Average Q} \\ &+ \beta_3 \times \text{Diversity} + \epsilon \end{aligned} \quad (6)$$

$$\begin{aligned} \text{Absolute Value Added by Allocation} &= \alpha + \beta_1 \times \text{Firm Size} \\ &+ \beta_2 \times \text{Inverse Average Q} + \beta_3 \times \text{Diversity} \\ &+ \beta_4 \times \text{Price/Earnings} + \epsilon \end{aligned} \quad (7)$$

As one can observe in Equations 5, 6, and 7, our independent variables include controls

for heterogeneity among business lines and companies: ‘firm size’, inverse average Q’, as well as ‘price/earnings’ ratio. We measure the firm size by taking the natural logarithm of insurance companies’ sales. The inverse average Q is our proxy for investment opportunities for each segment. Besides, the price/earnings ratio is our proxy for a market valuation of insurance companies. We exclude the typical business effects of market valuation, investment opportunities, and size of the company to focus on the effect of diversity on the absolute value added. We employ three regression models to attest to the stability of the diversity coefficient across all three regressions.

	<i>Dependent variable: Absolute Value Added by Allocation</i>		
	(1)	(2)	(3)
Firm Size	−0.06342*** (0.01014)	−0.06900*** (0.01005)	−0.06892*** (0.01001)
Inverse Average Q		0.00007*** (0.00002)	0.00008*** (0.00002)
Diversity	−0.94171** (0.37773)	−0.96426*** (0.37002)	−1.07057*** (0.37273)
Price/Earnings			0.00124* (0.00066)
Constant	0.35577*** (0.06502)	0.25602*** (0.06926)	0.22356*** (0.07109)
Observations	296	296	296
R ²	0.13067	0.16884	0.17883
Adjusted R ²	0.12474	0.16030	0.16754
Residual Std. Error	0.22249 (df = 293)	0.21792 (df = 292)	0.21698 (df = 291)
F Statistic	22.02057*** (df = 2; 293)	19.77262*** (df = 3; 292)	15.84331*** (df = 4; 291)

Table 11: *Reinsurance Efficiency and Diversity Trap.*

This table presents regression results for the absolute value added by allocation to assess the influencing factors upon capital allocation efficiency in insurance business lines. The models include explanatory variables for firm size, investment opportunities (inverse average Q), and market valuation (price/earnings ratio). Higher diversity in investment opportunities within business lines is associated with reduced efficiency of capital transfers, favoring companies with lower investment opportunities. Diversity represents the heterogeneity among insurance companies within a business line regarding investment opportunities. One can obtain the measure of diversity using Equation 4. This measure of diversity represents the standard deviation of asset-weighted Tobin’s Q of each insurance business line divided by the equally weighted Tobin’s Q of each business line. It aims to capture the diversity of business opportunities of insurance business lines. The absolute value added by allocation measures the efficiency of capital transfers within the business line. One can obtain the absolute value added by allocation using Equation 3. Standard errors are in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% level.

Table 11 presents the regression output to analyze the efficiency of reinsurance allocation within each business line which we measure by the absolute value added by allocation. The results indicate that higher diversity reduces the absolute value added by allocation at a 1 percent significance level. This finding implies that one standard deviation increase in investment opportunities, which we measure using Tobin’s Q, leads to a more inefficient capital allocation. Therefore, when diversity increases, the capital transfers are to insurance companies with low investment opportunities leading to lower absolute value added through reinsurance reallocation of capital.

Other results show that at a 10 percent significance level, insurance companies with a

higher market valuation or P/E ratio receive more absolute value added by allocation. This finding corresponds to the general expectation that the company's market valuation is an adequate estimate of investment opportunities. Therefore, companies with better market valuations receive more capital as market participants expect them to have better investment opportunities.

Additionally, the absolute value added by allocation reduces with the firm size and for business lines with high-on-average investment opportunities, as coefficients for firm size and inverse average Q indicate. Therefore, larger insurance companies and business lines with high investment opportunities typically receive less value added through reinsurance allocation. These findings suggest that smaller companies can typically benefit from reinsurance capital reallocation arrangements as well as business lines that are inefficient and unprofitable. Therefore, the reinsurance arrangement within the same lines of a business depicts more of a 'socialistic' allocation mechanism, which is an interesting finding given that there is a lack of direct ties among these insurance companies.

In general, the results suggest that as the business line becomes more diverse regarding the investment opportunities of insurance companies, the more inefficient the reinsurance allocation within this business line becomes. Besides, the other findings support the notion of 'socialism' or inefficient capital reallocation which is in line with Scharfstein & Stein (2000). The R-squared values range from 13.07% to 17.88%, which indicates, in combination with residual statistics, the relatively high explanatory power of the model and the low dispersion of fitted values.

In addition, we perform the Loess procedure to gain new insights into the relationship between diversity and absolute value added by allocation, as Figure 13 shows. The visual representation confirms former conclusions regarding the impact of diversity on the efficiency of reinsurance capital reallocations at a low level of diversity. In that regard, the findings correspond to Rajan et al. (2000) with respect to the coefficients and explanatory power of regression models.

However, upon further non-linear examination, one can observe that the absolute value added by allocation is negative and reduces only at low levels of diversity (0.00 – 0.10). For higher levels of diversity (0.15 – 0.30), one can observe a positive relationship between diversity and absolute value added by allocation.

Intuitively, when discrepancies among insurance companies are low, the transfers are likely to follow in the 'wrong' direction because performing a capital allocation to the insurance company with the best investment opportunities is difficult. However, when there is a clear difference regarding insurance companies' investment opportunities, the

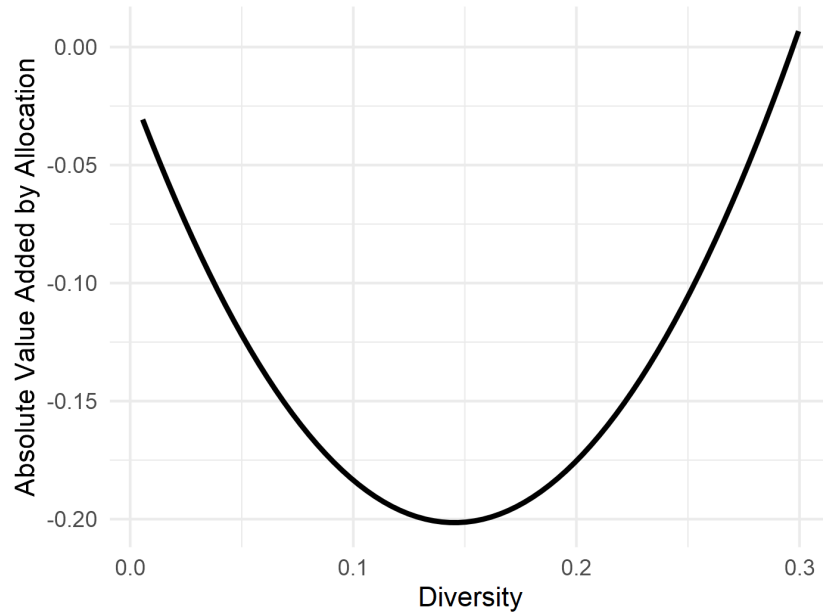


Figure 13: *Loess Regression for Inefficiency of Diversity*

This figure illustrates the relationship between diversity and the absolute value added by allocation. Diversity represents the heterogeneity among insurance companies within a business line regarding investment opportunities. One can obtain the measure of diversity using Equation 4. This measure of diversity represents the standard deviation of asset-weighted Tobin's Q of each insurance business line divided by the equally weighted Tobin's Q of each business line. It aims to capture the diversity of business opportunities of insurance business lines. The absolute value added by allocation measures the efficiency of capital transfers within the business line. One can obtain the absolute value added by allocation using Equation 3.

transfers should follow in the 'right' direction because one has more certainty regarding the investment. One can also observe that when there is almost no diversity in the business line, the absolute value added is almost zero due to the lack of economic significance of wrong transfer because all insurance companies are alike.

The lack of alignment of risk profiles and investment opportunities within the business lines can lead to inefficient allocation of resources and to a diversity trap for some insurance business segments, which have low levels of diversity because the absolute value added through capital transfers is negative and falls until a certain point as one can see in Figure 13. Understanding these inefficiencies can guide the insurance companies' capital allocation strategy for potential optimizations, partnerships, and enhancement of risk management strategy for business lines with low levels of diversity.

Table 12 reports the level of diversity for each major insurance business line. For the following discussion, one should reconcile Table 12 with Figure 13. In particular, Table 12 shows that the business lines which are most vulnerable to value-reducing reallocation are mortgage guarantee and managed care. Alternatively, life and health, property and casualty, multiline, on one side of the U-curve, as Figure 13 shows, and financial guarantees, on the other side of the U-curve, are the business line with the most efficient capital allocations. One can observe both of these implications by mapping back diversity to Figure 13 and deriving the absolute value added. Intuitively, the difference between the most efficient and the most inefficient business lines is that the most efficient insurance lines possess the capacities for long-term risk management, deep actuarial and financial expertise, and are insensitive to market downturns. On the other side, the most inefficient business lines have more stringent regulatory restrictions and higher exposure to economic downturns.

Business Line	Diversity
Life and Health	0.0056
Multiline	0.0095
Property and Casualty	0.0100
Reinsurance	0.0450
Insurance Broker	0.0710
Managed Care	0.0982
Mortgage Guaranty	0.1143
Financial Guaranty	0.2996

Table 12: *Business Line Diversity.*

This table provides diversity levels for major insurance business lines. These diversity values are linked to the efficiency of capital allocation shown in Figure 13. One can obtain the measure of diversity using Equation 4. This measure of diversity represents the standard deviation of asset-weighted Tobin's Q of each insurance business line divided by the equally weighted Tobin's Q of each business line. It aims to capture the diversity of business opportunities of insurance business lines.

10 Conclusion

The analysis of the structure and complexity of the top 100 global insurance groups highlights that the business models of insurance groups are very diverse across regions. We show that the business strategy of insurance groups and their international diversification are driven by the characteristics of their regional insurance market. However, some patterns are global. Insurance remains the business of developed economies, with most international subsidiaries of insurance groups in advanced economies operating in other advanced economies (or offshore centers) rather than emerging markets.

Our analysis also suggests a potential transmission channel of macroeconomic shocks through the performance of the group subsidiaries between regions. We find that due to the current structure of groups, market stress in the US is likely to affect the performance of the European and Japanese insurers but would have a limited impact on the groups with HQs in the UK and China. Also, we find that the US and the Chinese insurance groups are isolated from the rest of the world.

The analysis of the relationship between group complexity and its size shows that the two measures are complementary. Furthermore, the correlation between group size and complexity is weaker for insurance groups compared to banking groups. Next, we explore the relationship between group complexity and its performance. We find that group performance is positively related to business complexity and the total number of subsidiaries in the group. However, it is unrelated to the geographic complexity.

We also explore the relationship between group complexity and its contribution to global risk sharing. We find that the major insurance groups tend to set up subsidiaries in regions with higher levels of financial development and higher sovereign ratings. We also provide some evidence that the offshore subsidiaries of insurance groups are set up to overcome the operation across multiple regulatory regimes and to circumvent the operation in high capital control countries.

Regarding the role of insurance group complexity in reducing the insurance protection gap, we find evidence that business complexity helps to resolve the protection gap, unlike geographical complexity. Furthermore, we identify that insurance groups resolve the protection gap by increasing their market share, primarily in developing regions. Lastly, the most dominant insurance groups globally tend to expand and hold higher market shares in countries with less ability to withstand losses.

Furthermore, we analyze the impact of diversity in business opportunities on the efficiency of capital transfers among insurance companies. The results show that at high levels of

diversity, the efficiency of capital transfers improves. There is, however, an "allocation myopia" at low levels of diversity. The transfers at low levels of diversity are complex and usually lead to inefficient capital allocation due to difficulty in determining the most optimal transfer.

Our analysis is a first step to exploring the drivers and the consequences of the structure of the global insurance market and to provide motivation for future research. Understanding the drivers behind the positive relationship between the group business complexity and its performance, as well as the relationship between the insurance group structure and the map of regulatory regimes and regulation, sounds like a promising direction for future research.

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A Appendix

A.1 Geography Classification

Advanced Asia and Pacific	Australia, Japan, New Zealand
Advanced Euro area	Austria, Belgium, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Spain
Advanced Other Europe	Denmark, Liechtenstein, Norway, Sweden, Switzerland, United Kingdom
Advanced North America	Canada, United States
Developing Africa and Middle East	Algeria, Botswana, Burkina Faso, Cameroon, Côte d'Ivoire, Egypt, Ghana, Israel, Kenya, Kuwait, Lesotho, Madagascar, Malawi, Mali, Morocco, Mozambique, Namibia, Nigeria, Oman, Qatar, Saudi Arabia, Senegal, South Africa, Swaziland, Tanzania, Uganda, United Arab Emirates, Zambia, Zimbabwe
Developing Asia and Pacific	Azerbaijan, Cambodia, China, Chinese Taipei, India, Indonesia, Kazakhstan, Lao People's Democratic Republic, Malaysia, Nepal, Pakistan, Philippines, South Korea, Sri Lanka, Taiwan, Thailand, Vietnam
Developing Europe	Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Lithuania, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Turkey, Ukraine
Developing Latin America and Caribbean	Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Paraguay, Peru, Trinidad and Tobago, Turks and Caicos Islands, Uruguay, Venezuela
Offshore Centres	Aruba, Bahamas, Bahrain, Barbados, Bermuda, British Virgin Islands, Cayman Islands, Gibraltar, Hong Kong SAR, Lebanon, Macao SAR, Netherlands Antilles, Panama, Singapore

Table A.1: *Geography Classification.*

A.2 Host Countries Characteristics Summary Statistic

Variable	Count	Mean	SD	Minimum	Maximum
No Subsidiaries with Holding	121	67.63636	328.9017	1	3455
No Subsidiaries (Life)	121	7.528926	29.03793	0	302
No Subsidiaries (Non Life)	121	59.27273	297.3658	0	3125
GDP Growth (Annual %)	118	3.044364	3.031155	-15.67141	9.88759
GDP Per Capita (Current) USD\$	118	19748.6	22159.52	0	107361.3
Financial development index (2017)	110	.4176	.2260703	.091	.932
Insurance Penetration - Total	84	5.16306	5.72408	.27	38.829
Insurance Penetration - Life	84	3.024488	4.871173	.19	35.64
Insurance Penetration - Non Life	84	2.07744	2.39969	.03	16.65
Credit Rating (1-5)	102	2.872549	1.105088	1	5
Credit Rating ²	102	9.460784	6.389458	1	25
Regulatory Regime Rank (1-6)	121	3.867769	1.303471	1	6
Regulatory Regime ²	121	16.64463	10.83194	1	36

Table A.2: *Host Countries Characteristics Summary Statistics*

A.3 Host Country Characteristics Correlation Table

	Ins. Pen- etration Total	Ins. Pen- etration Non Life	Ins. Pen- etration Life	GDP Per Capita Growth	GDP Per Capita (USD)	GDP Growth Annual (%)	Fin. Dev. Index	Reg. Regime Rank	Credit Rating	Reg. Regime ²	Credit ₂ Rating ₂	Ins. Density (Total)	Ins. Density (Life)	Ins. Density (Non- Life)	Share of Foreign Market	Share of Domestic Market
Insurance Penetration Total	1.000															
Insurance Penetration Non Life	0.439	1.000														
Insurance Penetration Life	0.850	0.221	1.000													
GDP Per Capita Growth	-0.254	-0.144	-0.049	1.000												
GDP Per Capita (USD)	0.772	0.578	0.529	-0.261	1.000											
GDP Growth Annual (%)	-0.157	-0.184	0.029	0.902	-0.226	1.000										
Financial Development Index	0.504	0.513	0.273	-0.315	0.705	-0.329	1.000									
Regulatory Regime Rank	0.467	0.469	0.294	-0.235	0.689	-0.306	0.773	1.000								
Credit Rating	-0.490	-0.510	-0.345	0.054	-0.727	0.109	-0.584	-0.597	1.000							
Regime ²	0.472	0.472	0.294	-0.238	0.696	-0.301	0.762	0.996	-0.586	1.000						
Credit ₂ Rating ₂	-0.434	-0.454	-0.323	-0.013	-0.636	0.064	-0.539	-0.551	0.977	-0.537	1.000					
Insurance Density (Total)	0.968	0.331	0.856	-0.267	0.735	-0.144	0.384	0.368	-0.409	0.375	-0.344	1.000				
Insurance Density (Life)	0.944	0.203	0.872	-0.247	0.659	-0.116	0.307	0.304	-0.338	0.311	-0.282	0.990	1.000			
Insurance Density (Non-Life)	0.681	0.888	0.394	-0.263	0.836	-0.233	0.642	0.560	-0.617	0.566	-0.537	0.622	0.504	1.000		
Share of Foreign Market	0.013	-0.197	0.090	0.218	-0.098	0.076	-0.183	0.004	-0.011	-0.025	-0.014	0.085	0.127	-0.180	1.000	
Share of Domestic Market	-0.013	0.197	-0.090	-0.218	0.098	-0.076	0.183	-0.004	0.011	0.025	0.014	-0.085	-0.127	0.180	-1.000	1.000

Table A.3: *Host Country Characteristics Correlation Tables*

A.4 Offshore Business Analysis Summary Statistics

Variable	Count	Mean	SD	Minimum	Maximum
Number of subsidiaries in offshore centres	100	4.18	5.816	0	28
Share of offshore subsidiaries in the group	100	0.0593639	0.0854206	0	0.5882353
Number of regulatory regimes	100	2.78	1.33772	1	6
Diversity of regulatory regimes	100	0.4661176	0.3446425	0	1.527525
Average regulatory regime	100	5.200919	0.4424873	3.333333	6
No of subsidiaries in countries with high capital control	100	2.14	3.77129	0	19
Total number of subsidiaries	100	81.83	124.6714	1	981
Business Complexity	100	0.2977711	0.2195064	0.0046296	1
Geographic Complexity	100	0.5608935	0.2883616	0.0534058	1

Table A.4: Offshore Business Analysis Summary Statistics

A.5 Offshore Business Analysis Correlation Table

	Number of Regulatory Regime	Regulatory Regime ²	Diversity of Regulatory Regime	Average of Regulatory Regime	Total Size	No of Sub- sidiary with High Capi- tal control	Business Complexity	Geographical Complexity
Number of Regulatory Regime	1,000							
Regulatory Regime ²	0,976	1,000						
Diversity of Regulatory Regime	0,807	0,750	1,000					
Average of Regulatory Regime	-0,265	-0,244	-0,334	1,000				
Total Size	0,491	0,506	0,367	-0,267	1,000			
No of Sub- sidiary with High Capi- tal control	0,504	0,503	0,251	-0,015	0,446	1,000		
Business Complexity	-0,188	-0,176	-0,167	-0,085	0,064	-0,051	1,000	
Geographical Complexity	-0,782	-0,749	-0,753	0,165	-0,341	-0,460	0,235	1,000

Table A.5: *Offshore Business Analysis Correlation Table*

A.6 Insurance Protection Gap Summary Statistics

Variable	Count	Mean	SD	Minimum	Maximum
No of Subsidiary on High Protection Gap Group	100	12.3	17.22548	1	89
No of Subsidiary on High PG -Life-	100	2.63	3.889003	0	21
No of Subsidiary on High PG -NonLife-	100	9.67	15.09636	0	74
Share of subsidiary High Protection Gap (Total)	100	0.255421	0.3114368	0.0084746	1
Share of subsidiary High Protection Gap (Life)	100	0.0947165	0.1654098	0	1
Share of subsidiary High Protection Gap Non-Life	100	0.1607045	0.235825	0	1
Number of subsidiaries in the group	100	81.83	124.6714	1	981
Corporate group consolidated total assets, USD bn	100	285.5194	328.4732	20.4	2631.6
No of Reinsurance	100	7.77	13.80225	0	77
Business Complexity	100	0.2977711	0.2195064	0.0046296	1
Geographical Complexity	100	0.5608935	0.2883616	0.0534058	1

Table A.6: *Table A5. Insurance Protection Gap Summary Statistics*

A.7 Insurance Protection Gap (HPG) Correlation Table

	No of Subsidiaries in HPG Group (Total)	No of Subsidiaries in HPG, Life	No of Subsidiaries in HPG Non-Life	Share of Subsidiaries in HPG (Total)	Share of Subsidiary in HPG, Life	Share of Subsidiaries in HPG, Non-Life	Total Number of Subsidiaries	Total Assets (USD, bn)	No of Reinsurance subsidiaries	Business Complexity	Geographical Complexity
No of Subsidiaries in HPG Group (Total)	1,000										
No of Subsidiaries in HPG, Life	0,627	1,000									
No of Subsidiaries in HPG Non-Life	0,980	0,457	1,000								
Share of Subsidiaries in HPG (Total)	0,122	0,179	0,093	1,000							
Share of Subsidiary in HPG, Life	-0,099	0,163	-0,155	0,667	1,000						
Share of Subsidiaries in HPG, Non-Life	0,230	0,122	0,231	0,853	0,180	1,000					
Total Number of Subsidiaries	0,622	0,203	0,657	-0,224	-0,251	-0,120	1,000				
Total Assets USD bn	0,345	0,350	0,303	0,018	-0,042	0,054	0,247	1,000			
No of Reinsurance subsidiaries	0,456	0,262	0,452	-0,213	-0,224	-0,124	0,553	0,160	1,000		
Business Complexity	-0,081	-0,214	-0,037	0,172	0,395	-0,050	0,064	0,018	-0,216	1,000	
Geographical Complexity	-0,591	-0,448	-0,559	0,050	0,176	-0,058	-0,341	-0,289	-0,376	0,235	1,000

Table A.7: *Insurance Protection Gap (HPG) Correlation Table*