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"Divide et impera"? A financial assessment of the (de)concentration in the Brazilian reinsurance market

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Abstract

Reinsurers are companies that offer protection to insurance companies in the event of aggregate claims materializing beyond their retention capacity. However, little is known about the industrial organization in the reinsurance sector and its possible impact on the market, especially in Brazil, one of the last countries in the world to break the state monopoly performed by IRB. The objective of this work is to analyze the effects of the (de)concentration of the Brazilian reinsurance market on the measures of financial performance of reinsurers, more specifically their premium collection. For this purpose, traditional economic literature indexes were used, including the Herfindahl-Hirschman Index, the Concentration Ratio and Theil Entropy, using a model for panel data for longitudinal monitoring of market evolution. The database was officially extracted from SUSEP and contains 78,190 observations from 164 reinsurers, distributed in 22 lines of business (LOB), between Dec/2008 and Jul/2021. The results show that higher industry's concentration indices tends to generate lower premium collection for most LOB. For those LOB in which the Herfindahl-Hirschman and Theil Entropy index did not indicate this association, it was found that only the leading companies in these segments can get more premiums. Additionally, it should be noted that Local reinsurers are substantially favored over Admitted and Occasional reinsurers, which are severely affected by the variation in the industry's concentration and by other regulatory aspects. Other factors, such as portfolio diversification and belonging to an economic group, become significant when considering the relevance of the reinsurer category (Local, Admitted or Occasional) in operating in some segments.

Keywords: reinsurance market; Industrial Organization; concentration indexes; panel data

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1 Introduction

Reinsurance is an agreement that insurers resort to transfer part of its primary underwriting risks, by acquiring specialized insurance policies, in order to mitigate or reduce volatility and collectivize loss arising from high frequency and/or extreme severity events (Euphasio Junior & Carvalho, 2022). After all, in case of materialization of these phenomena, firms without reinsurance protection would be exposed to excess of losses over its holding capacity, increasing its ruin probability. On the edge, the absence of the instrument would compromise the insurance system's integrity, enabling a rise in systemic risk of this industry (Kanno, 2016; Kaserer & Klein, 2019).

In several countries in the world, this market is traditionally constituted by many private companies (Jean-Baptiste & Santomero, 2000). However, the Brazilian reinsurance market history is peculiar. Due to the protectionist economic policies from Vargas era, reinsurance operation in Brazil was kept under state monopoly of *Instituto de Resseguros do Brasil* (IRB) from its foundation in 1939 until the promulgation of the Constitution Amendment nº 13/1996, when monopoly was legally terminated. Despite the decree, the effective exercise of monopoly continued exclusively by IRB until the promulgation of Complementary Law nº 126/2007, when the official economic opening to other reinsurers occurred.

Nonetheless, the emancipation did not bring radical diversification in the market. If on one hand legislation fomented the economic opening of the activity, by the other, reinsurance's regulation kept protectionist, preventing the industry's development (Contador, 2014). After all, IRB remains as the dominant entity in Brazil, maintaining its market share around 30% since the economic opening[i]. In 2020, reinsurers have negotiated about BRL 16.8 billion, measuring up only about 6.12% of the total premiums of Brazilian insurers[ii]. As a comparison to the global market, which dealt over US$ 530 billion[iii], Brazil's participation represents only 0.44% of this total. To one of the biggest economies of the world, Faria (2007) argues that the low penetration index of reinsurance in Brazil denotes that this centered structure does not contribute to the market expansion, since it keeps price up and supply low, suppressing competitors and limiting the system's overall efficiency. Thus, Brazil could be losing opportunities not only in the insurance market, but also in the rest of the economy.

In addition to being inefficient in the economic standpoint, the industry's concentration in few companies means that the diversification risk principle is being violated (Borch, 1990). According to the Terra Brasis report[iv], the top five companies accumulated 64.8% of the reinsurance premiums in 2019, despite over 100 reinsurers operating in Brazil. Given that reinsurance contributes to damping the markets' excessive volatility (Cummins et al., 2011), the faulty redistribution of catastrophic risks are a serious breach to its social and economic protection role (Kaserer & Klein, 2019).

As a financial instrument, reinsurance is an operational leverage mechanism for insurers' primary risk underwriting (Barton, 2001; Shiu, 2020). Therefore, understanding the dynamics of concentration in the reinsurance market is also essential to the solvency aspect of insurance, because reinsurance agreement affects the managerial measures of portfolio risk returns under those companies' responsibility (Doherty & Tiniç, 1981). Besides reducing the volatility effects of the activities' loss ratio, it enables insurers to have bigger capacity to risk underwriting, increasing supply of insurance products and decreasing regulatory and solvency capital costs (Blazenko, 1986).

There are several studies about concentration in the insurance sector in Brazil, though always from the perspective of the insurer, with focus on the revenues and profit margins of these companies (Bonetti & Carvalho, 2020; Brás, 2019; Galiza, 1993; Gosmann, 2013; Peres et al., 2019). Yet, literature that look upon reinsurers is sparse, even in international context. In light of the dense organization in a few reinsurers, it is necessary a study that evidences the financial consequences of concentration growth in this market.

In face of this context, This paper aims to assess the effects of concentration in the Brazilian reinsurance market, from the actual breaking of the monopoly, in terms of the performance of reinsurers. Upon that matter, the elasticity of revenue from reinsurers as an outcome of the sector's competitive structure will be analyzed, by means of traditional indexes from Industrial Organization literature and data panel models. Thereby, we hope to shed light on the consequences of an eventual advancement in raising competitiveness to reinsurers by the regulator, providing a reduction of protection costs to insurers.

2 Theoretical Background

2.1 The weight of reinsurance

(Re)insurers follow strict solvency rules and prudential guidance of asset and liability management, stablished by regulatory authorities, as they are important to the economic development of a country (Wüthrich, 2015). However, the risk underwriting capacity of these entities is limited to its capital, so that any failures of these controls can result in the company's increase of ruin probability exposure (Moro & Krvavych, 2017). A way of overcoming this limitation is acquiring reinsurance (Areias & Carvalho, 2021; Euphasio Junior & Carvalho, 2022). This mechanism of contingent liability and assets cession between insurers dilute the systemic risk of the activity, while supports the financial viability of insurers (Bernard, 2013), so that even in the absence of regulation, there is sufficient motivation to insurers in sharing risks (Doherty & Tiniç, 1981).

Even so, the acquisition of reinsurance by insurers do not occur without inconvenience. Borch (1960, 1969) have pointed that the operating model between insurer and reinsurer is disharmonious, because conflicting interests and bargaining positions can favor a side more than the other. His works introduced the concepts of game theory in the analysis of market interaction of these entities, developing what later became known as *Stackelberg Solution*. This model, in reinsurance contracts, defines the reinsurer as the *leader*, which decides the protection price, and the insurer becomes the *follower*, which in turn decides the quantity of reinsurance to purchase. It is generally an interpretation used to treat the allocation problem considering market distortion (Cai Lemieux & Liu, 2016; Chi, Tan & Zhuang, 2020; Chun, Chi, Yann & Zhang, 2019).

In addition to Borch's works, some factors (e.g., the size of reinsurers, the spectrum of engagement in multiple markets, access to capital of big investors) also explain the privilege position of reinsurers to bargaining prices above subordinated insurers. Specifically, because they serve the purpose of promoting stability to the insurance market, reinsurers are entities that possess huge capital output (Besson, Dacorogna, De Martin, Kastenholz & Moller, 2009) under thorough prudential regulation (Harrington, 2005, 2009). Regulation in Brazil requires a minimum capital of BRL 60 million to local reinsurers, amount at least 4 times the minimum required to insurers, in addition to other rules on capital design for risk underwriting[v]. According to Biener et al. (2017), the costs and benefits of size and product diversification of

reinsurers is relevant to the industry, because bigger firms are characterized by high cost efficiency, while small firms show better performance only when specialized.

Extant research also recognizes the prevalence of distortion and intertemporal influence in the reinsurance market. Jean-Baptiste & Santomero (2000) argue that covenants supply occurs in a distorted environment, given that from the primary risk underwriting of the insurance to the reinsurance, every new transaction introduces a new layer of asymmetry due to the escalated transfer of liabilities without knowledge of the true assumed risks. In this context, the price of reinsurance is high. The conclusion of the study is that the lengthened relationship of an insurer with its reinsurer readjusts the pricing of the coverage, that are revised over retroactive information about the claim's portfolio.

In any case, it is indisputable that the presence of asymmetries is inherent to this business model, contributing to the hypothesis that the reinsurers' market domain is naturally striking. In this environment, it is notorious the junction of various factors that make an arbitrary market: the difference in size of the companies, capital entry barriers, asymmetric information and a lengthened dependency or subordination of the insurers. The situation deteriorates when markets are concentrated, in which imperfect competition can aggravate the arrangement between prices and insurer and reinsurer relationship.

2.2 Concentrated Markets

The Industrial Organization (IO) is a field of Economics that studies the structures, markets, and strategic interactions of firms, as well as the analysis of the competition setting and its consequences. To Plott (2016), the importance of conducting experimental studies is the possibility of showing that institutions and market practices can, in fact, exert influence on the industry's performance. Furthermore, he highlights that regular indexes from IO, such as *Herfindahl-Hirschman Index* (HHI) and *Concentration Ratio* (CR) can capture, with good adherence, the behavior we observe in the market.

Some authors indicate that concentrated markets impact insurance consumption. Evaluating the effects of concentration in specific insurance line of business (LOB), Cummins et al. (1972) analyze the concentration of life insurance in the United States. In this same LOB, Park & Lemaire (2011) investigate the influence of culture and other factors over life insurance demand in the Asian market. By using measures such as HHI, both studies point out that the demand in life insurance has a negative correlation with the index, suggesting that market concentration on few insurers decrease insurance purchase.

On non-life segments, Chidambaran et al. (1997) studied the American liability insurance LOB, analyzing possible determinants of price and efficiency. The concentration index was shown as a significant factor to the firms' performance. However, although it is plausible that efficient firms absorb bigger market share, there were no signs that substantiate this hypothesis, suggesting that concentration in the industry dismisses price competition, eased by the authorities' connivance towards antitrust laws. Following this premise, Dafny et al. (2012) analyze the longitudinal evolution of concentration on the American health insurance, paying attention to the tax growth on premiums over time. While investigating the influence of health insurance market consolidation over the fast increase of premiums, they confirm that Americans pay more on health insurance as insurers' market share grow.

Frequently, studies in the IO field analyze the concentration by observing the efficiency of companies. In contrast, Altuntas & Rauch (2017) perform an unusual analysis on the impact of concentration on the viewpoint of the financial sector's stability. By examining the financial

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effects of the most various insurer concentration proxies, they conclude that a higher level of concentration contributes to the financial weakening of insurance. This is compelling to regulators when evaluating the implementation of competition policies, in force of the rise in merge and acquisition affairs.

The constant exposure to catastrophic risks is one of the causes that reduce financial solidity, being this fact the major argument in favor of merge and acquisitions, so much from insurers to reinsurers. From this perspective, Outreville (2012) verified a global tendency on market share growth for reinsurer groups over the years, due to the concept that only big-sized players maintain competitiveness. Competition aspects are discussed by Blazenko (1986), who examined three settings for this market: the competitive market, the case considering transaction costs and the scenario for imperfect competition markets. Besides asserting that imperfect competition is a sufficient requirement to reinsurance, he also strongly suggests that concentration in the (re)insurance market is a determinant factor to reinsurance purchase.

The dynamics in IO also affects reinsurers that are subject to the same phenomena observed in the direct markets managed by insurers. Regarding efficiency, Cummins, Feng & Weiss (2012) details the influence factors that induce to reinsurance demand, assessing the ratio of reinsurance contracts that insurers center in each reinsurer. The consequence to limited diversification links revealed to be harmful to the performance of insurers. On the other hand, Biener et al. (2017), seeking to explain the global structure of the reinsurance market and the competition framework, they expose the trade-off between scaled diseconomies and efficiency gains. Using regression models, they estimate the correlation between profit and pricing as aftereffects of concentration coefficients, sustaining structure-conduct-performance (SCP)[vi] hypothesis for positive correlation between variables.

Finally, we deduce that the interdependence of the insurance industry indicates that negative externalities (spillovers) in the direct or reinsurance markets can affect the entire insurance chain. Therefore, understanding the reinsurance industry's setting and how it impacts insurers is of extreme importance to evaluate and dimension purchase risks, as reduction of ruin probability must be consistent with any resulting inconveniences of reinsurance acquisition.

2.3 Evidence from the Brazilian market

Upon the Brazilian reinsurance market opening, the country was one of the last countries in the world to still hold monopoly of reinsurance, along with Cuba and Costa Rica (Contador, 2014). For a long time, the protectionist role of IRB was to foment a "budding industry", for the country's lacking capitalization capacity and technical expertise to manage the insurance industry (Faria, 2007). Because of this fragility, the management and commercialization of insurance products were often incorporated to big banking conglomerates, being integrated to the country's financial system.

Kaserer & Klein (2019) suggest that, although the insurance sector represents only a small portion of the systemic risk of the global financial system, these entities frequently bear high levels of systemic risk, so much that they can be considered a critic element of the financial system. In Brazil, this become relevant when we speak of *bancassurances*, the strategic cooperation between banks and insurers that aims to offer insurance through bank channels (Benoist, 2002). Cardoso et al. (2018) and Silveira (2017) verify the competition scenario in the financial system, and attest the dense concentration of this sector. Hence, it is no surprise that bancassurances are behind nearly 60% of all insurance premium revenues in Brazil[vii]. This

shows how fundamental it is to assure that access to – and maintenance of – reinsurance contracts is optimized, to guarantee protection including the country's banking sector.

On insurance concentration studies in Brazil, Galiza (1993) was pioneer to evaluate the structural condition of this sector before monopoly breakage of IRB. Peres et al. (2019) applied IO concepts and tools to study specifically the effects on automobile insurance market, Gosmann (2013) sought to expand the analysis to all other non-life insurance, and finally, Rodriguez & Prado (2007) embrace the entire insurance, pension and capitalization market. The results, in general, signals that the concentration index of almost all insurance LOBs is overly high, evidencing the suspicion that the insurance market in Brazil is an oligopoly. Moreover, they point out other weakness, such as excessive dependence on the banking sector and low efficiency of the firms if compared to countries with a more developed insurance market.

Yet, all these works used OLS regression models, not being possible to observe the time dimension perspective. Bonetti & Carvalho (2020) were pioneers in using panel data to capture the evolution of concentration of all insurance LOBs and its effect on the market, through HHI, CR and Theil's Entropy. The indexes revealed an increase in the concentration of the industry; however, the financial effect was the decrease in premium revenues without shrinkage of profit margins.

No papers about reinsurers' concentration were found in Brazil. Following the model used by Dafny et al. (2012), and broadening the works by Bonetti & Carvalho (2020), this present article aims to offer empirical arguments, through traditional IO indexes, to analyze the longitudinal effects on the impact of little competition among Brazilian reinsurers. Notably, this is the first paper to use panel data models. At the same time, we seek to contribute to the discussion of a hardly explored sector, bringing evidence to foment the systemic robustness to (re)insurance industry about the financial performance of these entities.

3 Methodological Procedures

3.1 Concentration Indexes

This section will follow closely Bonetti & Carvalho (2020). Aligned to the arguments brought in previous sections, the study of market concentration is of extreme importance, considering the possible adverse impacts on the anti-competitive structure of the reinsurance sector. For this reason, concentration indexes are frequently used as instruments to measure empirically the level of competitiveness, enabling a derivation of analysis and conceiving explanations. However, due to methodological limitations of each index, Kon (1999) declares that it is necessary to adopt more than one index to capture distinctively the market's behavior. Therefore, following the methodological procedures of the studies explored in the former section, we will use *Concentration Ratio* (CR), *Herfindahl-Hirschman Index* (HHI) and *Theil's Entropy* (TE), defined on the following subsections.

3.1.1. Concentration Ratio (CR4 and CR8)

The Concentration Ratio (CR) is a metric that measures the level of participation of a set quantity of firms in a delimited environment. In our work's scope, we consider as measuring unit the volume of direct premium revenues. Equation 1 defines the calculation of the index:

$$CR_k = \sum_{i=1}^{k} S_i \qquad (1)$$

in which S_i refers to the proportion of the *i-th* firm in the market being studied. Specifically, we are interested in $k = 4$ and $k = 8$, arbitrary values commonly found in empirical literature.

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3.1.2. Herfindahl-Hirschman Index (HHI)

Introduced by Herfindahl (1950) and Hirschman (1945), this index represents the quadratic sum of the market quota share of each firm. Every company in the scope of the industry is considered to the calculation, given by:

$$HHI = \sum_{i=1}^{N} S_i^2 \tag{2}$$

The N factor represents the total number of companies active in the market. Contrasting from the CR, HHI considers the proportion of all firms when S_i quotas are squared. The expected values vary from $1/N$ (market uniform distribution) to 1 (monopolistic scenario). Consequently, if N is sufficiently large, we have a perfect competition scenario.

3.1.3. Theil's Entropy (TE) Index

The Theil's Entropy (TE) Index complements the HHI index, since HHI is considered sensitive to the entry of the new companies. The TE index was incorporated to IO literature by Theil (1967), deriving out of information theory.

$$ET = \sum_{i=1}^{N} S_i \ln\left(\frac{1}{S_i}\right) \tag{3}$$

This measure represents the inverse magnitude to concentration: e.g., its decay occurs as the sector's concentration increases. Therefore, if $TE = 0$, concentration is maximum.

3.2 The Model

Reinsurance direct premium elasticity will be measured against the sector's concentration variation (using different concentration indexes), controlled by firm's characteristics for both fixed and random effects. Equation 4 specifies the mathematical representation of the model.

$\ln(Premiums_{i,r,t}) = \beta_0 \ln(Premiums_{i,r,t-1}) + \beta_1 \ln(GDP_t) + \beta_2 Ranking8_{i,r,t} + \beta_3 PortDiv_{i,r,t} + \beta_4 ConcInd_{r,t-1} + \beta_5 Group_{i,r,t} + \beta_6 PortDiv_{i,r,t} \times Admitted_{i,t} + \beta_7 PortDiv_{i,r,t} \times Eventual_{i,t} + \beta_8 ConcInd_{r,t-1} \times Admitted_{i,t} + $

$+\beta_9 ConcInd_{r,t-1} \times Eventual_{i,t} + \beta_{10} ConcInd_{r,t-1} \times Ranking8_{i,r,t} + \beta_{11} ConcInd_{r,t-1} \times Group_{i,r,t}$ (4)

Using indexes presented in the former subsections, the purpose of this model is to capture the effect that evolution on the industry's concentration has over time in insurance companies. Note that, concerning variables attributed to concentration indexes ($\acute{I}ndConc_{r,t-1}$), we applied a 1-period lag, following Bonetti & Carvalho (2020) and Dafny, Duggan & Ramanarayanan (2012). Thus, the endogeneity effects are addressed, lessening the loss in association of the impulse-response between premium revenue ratio and concentration indexes.

Regarding other explanatory variables that were not dealt in the former section, we have:

$PortDiv_{i,t}$: depicts the portfolio diversification in terms of insurance LOB, assuming values from 0 to 1, as expressed by Equation 5. This parameter signals the level of specialization in each LOB, to every reinsurer. Thus, the higher the index, the greater the quantity of r LOB is in which reinsurer i operates at instant t.

$$PortDiv_{i,t} = 1 - \sum_{r=1}^{R} \left(\frac{Direct\ Premiums_{i,r,t}}{Direct\ Premiums_{i,t}}\right)^2 \tag{5}$$

$\ln(GDP_t)$: GDP logarithmic at instant t, controlling the economic development of the country.

$Group_{i,r,t}$: dummy variable that captures whether reinsurer i belongs to an economic conglomerate at instant t.

$Ranking8_{i,r,t}$: dummy variable that indicates whether the i-th reinsurer belongs to the top 8 companies, under the revenue criterion, at the r LOB at time t.

$Admitted_{i,t}$: dummy variable that indicates if reinsurer i is considered an Admitted reinsurer at instant t;

$Eventual_{i,t}$: dummy variable that indicates if reinsurer is classified by the regulator as an Eventual reinsurer at time t. In event of not being classified as Admitted nor Eventual, the reinsurer is considered Local.

4 Result Analysis

4.1 The data

The database used for the analysis of the Brazilian reinsurance market was extracted from the SUSEP's Statistics System (SES), the official information bureau, which is loaded monthly by companies on their own via Periodic Information Form (FIP). Here, timeframes are important. According to SUSEP Circular nº 364/2008, only Local reinsurers were obliged to fill FIP, so that it was not possible to observe Admitted and Eventual reinsurers' data. Such condition remained as it was until 2015, when Circular nº 517/2015 changed this understanding. Therefore, only from 2015 on all reinsurers were obligated to inform their transactions data to SUSEP (the local authority).

To characterize the evolution in each LOB, data was organized in panel to enable the follow-up of all variables over time. For the reasons already explained, from Dec/2008 to Dec/2014 there is only information of Local reinsurers. From Jan/2015 to Jul/2021, we have information from all companies. We merged the database that contains transaction values with the one with shifting values per reinsurer assignee. These databases consist of information from 164 reinsurers, of which 17 are Locals, 43 are Admitted and 104 are Eventuals. Together, they negotiated in average BRL1.8 billion per month along the last 6 years. All monetary amounts are expressed in constant currency of Jul/2021, adjusted by IPCA inflation index.

4.2 Descriptive Statistics

Selecting only the companies' code for reinsurers, we have 78,190 historic observations, distributed in 22 LOB, which descriptive statistics are presented in Table 1.

Table 1 – Reinsurance LOBs and average monthly revenues (2008-2021).

Line of Business	Type	Average Monthly Revenues	
01 – Property	Non-Life	BRL	267,591,764
02 – Special Risks	Non-Life	BRL	20,517,531
03 – Liability	Non-Life	BRL	50,982,501
04 – Hull	Non-Life	BRL	8,581,656
05 – Automobile	Non-Life	BRL	35,642,462
06 – Transportation	Non-Life	BRL	56,507,954
07 – Financial Risks	Non-Life	BRL	125,946,694
08 – Credit	Non-Life	BRL	3,619,436
09 – Collective Life	Life	BRL	44,290,448
10 – Housing	Non-Life	BRL	5,961,669

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11 – Rural	Non-Life	BRL	115,705,120
12 – Others	Non-Life	BRL	7,040,440
13 – Individual Life	Life	BRL	12,262,930
14 – Maritime	Non-Life	BRL	15,133,166
15 – Aeronautic	Non-Life	BRL	24,823,696
16 – Microinsurance	Non-Life	BRL	478,992
17 – Oil	Non-Life	BRL	87,420,113
18 – Nuclear	Non-Life	BRL	15,008,854
19 – Health	Non-Life	BRL	2,524,065
20 – Overseas Acceptance	Non-Life	BRL	32,321,933
21 – Overseas Branch	Non-Life	BRL	517,980
22 – Life Pension	Life	BRL	321,685

Source: own elaboration

Notably, to reinsurers, the Non-Life market is about 14 times bigger than Life, the opposite of the insurance market (Bonetti & Carvalho, 2020). This is due to the fact that, despite legislation allowing reinsurance purchase from Local firms[viii], pension funds tend to lean on the corporate structure of its employer[ix]. Since this segment has the biggest representation of the Non-Life proceeds, this LOB renders fewer premium revenues. It is important to highlight that, in this database, some LOB do not show data to the entire period (e.g., Individual Life, Maritime, Aeronautics), because they were licensed after the beginning of registry of these data.

**Table 2 –** Descriptive statistics of the reinsurers operating in Brazil

Reinsurer	Premiums (in BRL million)	Claims (in BRL million)	PortDiv
All	1.6 (10.2)	1.0 (10.7)	0.44 (0.29)
IRB	18.5 (46.5)	13.1 (47.3)	0.77(0.07)

Note: standard deviation in parentheses.   Source: own elaboration

By comparing the companies' indexes, we realize the presence of a big distortion caused by a relevant player, so we isolated the market performance from IRB. We verify that the volume of premiums, claims, as well as portfolio diversification index of IRB (the biggest Local reinsurer) are significantly dissonant from the rest of the market (Table 2). By Figure 1, we evidence the disparity of IRB's caliber compared to its competitors.

Figure 1 – Total direct premiums evolution of the top 5 reinsurers (2009-2021)
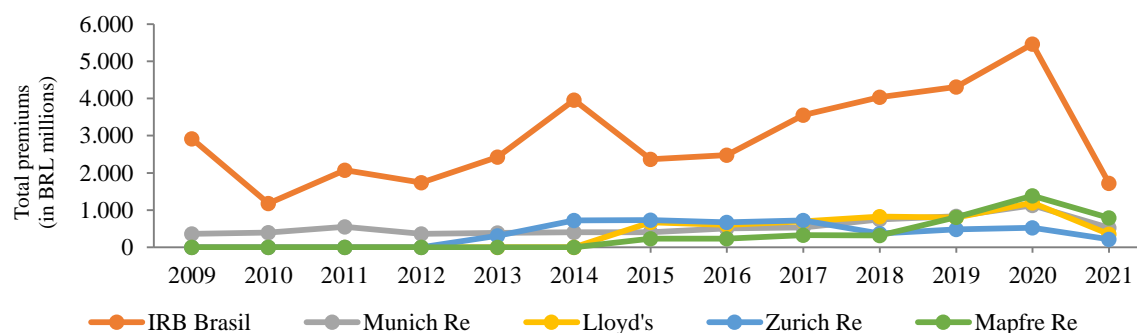
Source: own elaboration

The evolution of the average concentration indexes (CR4, CR8, HHI and TE) of the biggest (01–Property) and the smallest active (05–Automobile) LOB were shown in Figures 2 and 3, evidencing the behavioral discrepancy between different LOB.

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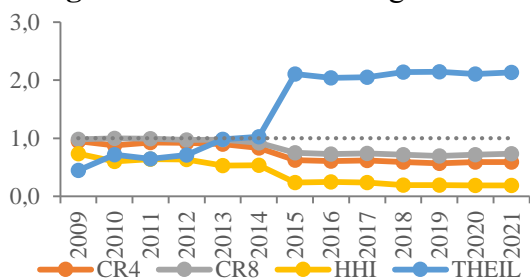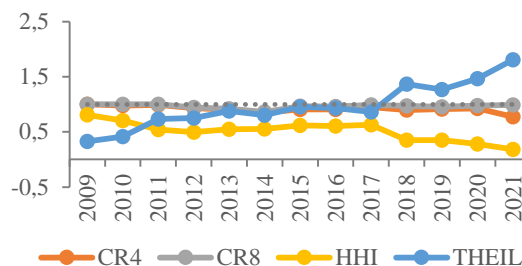**Figure 2** – LOB 01's average indexes   **Figure 3** – LOB 05's average indexes

Source: own elaboration.

We highlight that there is a structural break in the transition between 2014 and 2015, caused by the junction of different databases while trying to incorporate the transactions of Admitted and Eventual reinsurers that began to report on FIP. Under a competitive perspective, data until 2014 showed only 60% of the market. With the addition of the Admitted and Eventual's data, concentration indexes were diluted. Hence, a clearer observation of the market competitiveness took place. However, CR4 and CR8 indexes continue to indicate concentration upon the top players.

4.3 Model Estimation Results

The purpose of the panel data regression in our work is to capture how the evolution of the reinsurance market concentration is related to the entities' revenues, regarding its own features. This model can capture not only the longitudinal evolution of a same company, but also cross section between firms. Among benefits of panel data are detection and measuring of statistic effects that pure time series structures or cross-sectional data cannot capture, besides minimizing the aggregation bias of a single series. Furthermore, this model incorporates individual heterogeneities, generating more information, more variability and less collinearity between variables (Hsiao, 1985).

Initially, we attempted estimating using GMM models to evaluate dynamic panel data models to address endogeneity problems. Proposed by Arellano & Bond (1991), their model includes lagged dependent variables as regressors, which could cut off possible individual effects of reinsurers. Nevertheless, due to the concentration indexes properties, the use of GMM regression became limited, since indexes among companies are invariant as they represent an inherent characteristic of the market in a given period and LOB. Consequently, it was not possible to adopt this strategy.

However, as explained, we opt to insert as explanatory variables the lagged concentration index and the autoregressive premium revenue, aiming to mitigate the endogeneity bias (Dafny et al., 2012). To determine which one was a more consistent model, we performed the Hausman Test to verify whether fixed or random effects was more adherent to the regression model to each LOB (Table 3). As expected, it turns out that the fixed effects model was shown to be better to all LOB, as the cross-sectional variability of the database is small. Last but not least, we chose to present the results considering HHI as the control variable. We estimated all models for the other indexes and LOB, which can be provided upon request.

By Table 3 one can see that GDP is a relevant explanatory factor to premium revenues. There is evidence that the economic scenario is neutral or positively associated to the insurance market development (Bonetti & Carvalho, 2020; Outreville, 1998), but to reinsurance market the results are inconclusive (Outreville, 2012). Our estimates suggests that increase in GDP is

linked to higher premium revenues to 05–Automobile, 07–Financial Risks, 13–Collective Life and 17–Oil LOB. This finding is aligned with Outreville (1990) and Park & Lemaire (2011), because the coverage of the underlying assets are related to elastic demand products. On the other hand, negative coefficients found in other LOB can be related to the impacts of Operation Car Wash on the Brazilian Economy (Rensi & Carvalho, 2021) on the rise of widespread risk perception in asset arrangement and third-party liability, depicted by LOBs 01-Property and 03-Liability, having occurred in a period of intense retraction of the country's GDP[x].

The main effect of the indicator variable $ranking8_{i,r,t}$ is at the expected direction: it is significant and always positive. Moreover, we verified that premiums have positive and a compelling autoregressive structure, signaling the inertial fundraising behavior of this industry. When we analyze the expected effect of the portfolio framework, keeping everything else constant, Local reinsurers with bigger diversification tend to have higher premium revenues. For Admitted and Eventuals the opposite happens: less diversified portfolio firms have collected more premiums. Therefore, specialization tends to be a profitable factor to these companies.

On the *group* dummy, we verified that the composition of the top 8 companies for all LOB contains firms that belongs to an economic conglomerate. Still, the negative sign of the interaction between concentration and the conglomerate dummy indicates that increase in concentration is related to decrease in revenues of firms belonging to these groups. This occurs on all line of business. Moreover, it is interesting to point out a peculiarity of the Brazilian reinsurance market: the majority of reinsurers that takes part in an economic group are classified as Admitted and Eventuals, and few are Local reinsurers in this category. This fact suggests that, in scenario of higher levels of concentration, the beneficiaries with elevated premiums were mainly Local reinsurers.

This situation could have been aggravated by CNSP Resolution no.224/2010 and no.225/2010, which respectively, banned intragroup reinsurance or retrocession operations with overseas reinsurers (later the CNSP Resolution no.232/2011 limited it to 20% for each contracted coverage) and eliminated the preference system, replacing it with a market reserve. Such rules could have disfavored the basic structure of the sector, because not only they discouraged the operations of Admitted and Eventual companies, but also favored substantially the Local reinsurer's revenues. Afterwards, the CNSP Resolution no.322/2015 (ratified by CNSP Resolution no.325/2015) sought to soften the restrictions, reestablishing the degree of market opening.

On the main effect of HHI, variations on the concentration index does not produce significant effects of less premium revenues to Local reinsurers, except for 05–Automobile and 08–Credit LOB, in which increase in concentration lead to higher premium revenues. Yet, for Admitted and Eventuals, the effect of concentration is extremely significant. Increase in concentration is related to little or no effect to Local reinsurers, but it can impact positively the revenues of Admitted and Eventual firms. By observing the interaction between concentration index with *Ranking8* in LOBs 05–Automobile and 13–Individual Life, there is indication that the rise of concentration, *caeteris paribus*, is associated to reduction of the top 8's revenues in their segment. This could mean that only top companies are beneficiated by the scenario, making other firms lose revenue shares. Parallel to that, the association between concentration index and economic group dummy indicates that there is relationship between higher concentration and lower revenues to firms that belongs to economic conglomerates. In other

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words, Admitted or Eventual reinsurers that take part in economic groups have their revenues attenuated.

Lastly, we highlight that there were no significant differences when comparing the model's results for each index, for which we decided to maintain only the results for HHI. Although different indexes seek to integrate distinct perspectives of the sector's organization, we verify that the competitive adjustment of the reinsurance market is deeply concentrated in a few players. Thereby, the measuring of the participation and inequality of the sector captures mainly the effect of the top reinsurers, while the distribution of market share on other firms is pulverized.

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Table 3 – Panel data regression results using lagged HHI as explanatory variable

Groups of LOB	1		3		5		6		7		8		11		13		17	
HHI	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
$Premiums_{t-1}$	0.32***	0.01	0.43***	0.01	0.46***	0.02	0.39***	0.01	0.49***	0.01	0.72***	0.01	0.64***	0.01	0.50***	0.02	0.14***	0.02
$\ln(GDP_t)$	-0.99	0.77	-0.44	0.78	3.80**	1.31	-0.44	0.91	-0.01	0.73	-4.70***	0.58	0.03	1.01	2.71.	1.40	1.13	2.80
$Ranking8_{i.r.t}$	1.45***	0.22	1.07***	0.21	5.94***	0.50	2.16***	0.27	1.69***	0.18	0.15*	0.07	1.25***	0.31	4.59***	0.63	6.26***	0.61
$PortDiv_{i.t}$	4.12***	0.50	4.74***	0.46	5.28***	0.61	6.15***	0.49	3.71***	0.44	2.64***	0.36	3.75***	0.53	2.49***	0.60	3.96*	1.93
$ConcInd_{r.t-1}$	-1.34	1.54	-2.09	1.56	5.44***	1.65	0.06	1.73	-3.11.	1.78	2.43***	0.41	-1.80	1.27	0.67	1.91	-1.44	3.08
$Group_{i.t}$	0.66	0.65	0.66	0.62	0.28	1.45	0.51	1.46	1.13.	0.60	0.95**	0.33	1.03	0.73	1.86*	0.72	0.55	2.55
$PortDiv_{i.t}$*Admitted	-0.29	0.63	-0.19	0.58	-4.50***	0.92	-1.16.	0.64	-3.25***	0.58	-2.54***	0.45	-1.56*	0.68	0.63	0.97	1.26	2.35
$PortDiv_{i.t}$ *Eventual	2.29***	0.58	1.68**	0.55	-4.86***	1.01	-0.04	0.61	-2.46***	0.54	-2.68***	0.48	-1.51*	0.70	1.05	0.93	2.23	2.13
$ConcInd_{r.t-1}$*Admitted	3.43*	1.70	5.26**	1.90	2.15*	0.89	2.98*	1.51	5.80.	2.96	-0.68*	0.30	4.17***	1.00	4.93*	1.94	1.77	1.41
$ConcInd_{r.t-1}$*Eventual	5.71***	1.45	6.02**	1.83	-0.02	1.23	3.29*	1.53	6.38*	2.73	-0.21	0.32	3.23**	1.22	3.28	2.77	0.32	1.40
$ConcInd_{r.t-1}$*Ranking8	1.34	1.00	2.00.	1.15	-5.17***	0.91	-0.51	1.26	2.77*	1.19	0.78**	0.26	-0.02	0.79	-2.81.	1.68	0.94	1.22
$ConcInd_{r.t-1}$*$Group_{i.t}$	-3.16*	1.30	-2.61*	1.21	-2.05	1.49	-2.28.	1.36	-5.80***	1.47	-2.43***	0.34	-1.03	1.10	-4.11***	0.97	-0.40	3.19
Nº of observations	8867		7009		3078		6112		6090		2656		4307		2444		1962	
Nº of firms	152		127		68		119		114		44		99		67		97	
Periods of observations	152		152		152		152		152		152		152		128		49	
R^2	0.229		0.361		0.439		0.335		0.347		0.708		0.519		0.549		0.310	
R^2 Adjusted	0.212		0.346		0.423		0.318		0.332		0.701		0.506		0.532		0.261	
Hausman Test (p-Value)	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
Type of estimation	Fixed		Fixed		Fixed		Fixed		Fixed		Fixed		Fixed		Fixed		Fixed	

"." Significant at 10%; "*" Significant at 5%; "**" Significant at 1%; "***" Significant at 0,1%.

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5 Final Remarks

This paper aimed to provide evidence about the effects of the Brazilian reinsurance market (de)concentration over time, using panel data regression techniques. Moreover, we sought to understand the impact of the main idiosyncratic features and how the players are structured in the market, since Brazil was one of the last countries in the world to maintain state monopoly in this economic industry until the beginning of the 21st century.

The most relevant lines of business were analyzed under the main concentration indexes from empirical literature. Herfindahl-Hirschman Index (HHI) and Theil's Entropy (TE) inform us about the distribution of market share, while Concentration Ratio (CR) measures the market ratio concentrated in the top firms of each LOB. Therefore, this indexes complement themselves, enabling the formulation of possible explanatory relationships of the industry. However, we do not verify differences in their behavior when analyzing these measures, which could express that the industry's organization is deeply concentrated specially on the top reinsurers.

Higher concentration is a factor related to fewer premium revenues to the majority of lines of business. To those LOB in which HHI and TE did not point out this association, we could verify that only top companies of these segments collect more premiums. Thus, other firms are harmed with a concentrated industrial structure. Other factors such as portfolio diversification and economic group belonging turns out to be significant when we consider the relevance to the category of reinsurer (Local, Admitted and Eventual) in the LOB's operation.

As in Bonetti & Carvalho (2020), Peres et al. (2019) and Silveira (2017), we investigate the Structure-Conduct-Performance paradigm in the reinsurance operation in Brazil. Although top firms are beneficiated with a higher concentration in the market, there is no evidence that this result comes from a perception of market influence. Our evidence suggests that due to the legal-economic scenario of market protectionism, Local reinsurers were favored in spite of the others. Unfortunately, we could not assess aspects of Conduct-Performance of reinsurers due to the absence of data.

This paper is not out of some limitations. One of the biggest hardships of execution was obtaining a complete database in SUSEP. The capture of reinsurers' data was not officially regulated until 2015, so that any speculation before this period is limited. Additionally, although Admitted and Eventual reinsurers are now obliged to report transactions in FIP, they still do not report other detailed accounting data such as total assets, claims and commissions. Lastly, on the regression model, it was not possible to use dynamic GMM panel data regression, due to limitations caused by the invariability of concentration indexes between companies, since they are general market variables.

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