

# Automobile insurance in Brazil: market concentration and demand

Vivileine Maria Peres<sup>1</sup>

 <https://orcid.org/0000-0003-3432-6319>

Email: vivileineviv@hotmail.com

Wilfredo L. Maldonado<sup>2</sup>

 <https://orcid.org/0000-0001-9576-9418>

Email: wilfredomaldonado86@gmail.com

Oswaldo Candido<sup>3</sup>

 <https://orcid.org/0000-0002-4850-6989>

Email: osvaldoc@ucb.br

<sup>1</sup> Banco do Brasil, Diretoria de Estratégia e Organização, Brasília, DF, Brazil

<sup>2</sup> Universidade Federal de Goiás, Faculdade de Administração, Ciências Contábeis e Ciências Econômicas, Programa de Pós-Graduação em Economia, Goiânia, GO, Brazil

<sup>3</sup> Universidade Católica de Brasília, Escola de Humanidades, Negócios e Direito, Programa de Pós-Graduação em Economia, Brasília, DF, Brazil

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## ABSTRACT

This paper studies two aspects of the automobile insurance market in Brazil: first, it determines the degree of competition among insurance companies, and second, it estimates and analyzes the demand for automobile insurance. Most of the studies on the automobile insurance market in Brazil analyze the performance of the firms in this sector or present regional studies of the demand for insurance and its determinants. Thus, this study innovates both in showing the competition among the firms and estimating the demand for insurance in the country. The relevance of this research lies in the sequential and ordered way it analyzes the demand in a sector. Firstly, it identifies the type of competition that takes place in the sector and then, based on this, it proposes a structural framework based on optimizing decisions for estimating the price, income, and market power elasticities of demand. Furthermore, analyzing the insurance industry is of the utmost importance since it moves significant amounts of financial resources and provides an essential service in the economy. With information about the market structure and demand profile in the automobile insurance sector it is possible to propose strategic policies for individual firms as well as for the whole sector in order to introduce more efficiency. To analyze the degree of competitiveness, several concentration indices were calculated using annually-aggregated monthly data on the premium paid to all the automobile insurance firms in the period from 2001 to 2016. To estimate the demand for automobile insurance, half-yearly data from 2002 to 2010 for each one of the 27 federative units of Brazil were used. Two main findings are presented in this study. First, we find evidence of little concentration in the Brazilian automobile insurance market, with shares being well distributed among the players. Second, we estimate the demand for automobile insurance in Brazil and find a price-elasticity of -0.47 in the short run and -1.33 in the long run, while the lagged profitability has a negative impact on the amount insured: -0.21 in the short run and -0.59 in the long run. Income does not significantly influence the demand for insurance in Brazil.

**Keywords:** automobile insurance market, competitiveness, market concentration, demand for insurance.

## Correspondence address

Vivileine Maria Peres

Banco do Brasil, Diretoria de Estratégia e Organização  
Rua 16 Sul, Lote 04, Apartamento 603 – CEP 38400-902  
Águas Claras – Brasília – DF – Brazil



## 1. INTRODUCTION

The Brazilian insurance market is one of the most important in the economy, not only because it provides protection against adverse events that can reduce personal or company wealth, but also because it moves large quantities of financial resources within the property incomes reported in the Integrated Economic Accounts. In 2016, the returns on investments attributed to insurance policy holders alone were R\$ 10.23 billion.

Brazil is characterized as presenting an insurance sector with a diversity of coverage and personalization. Coverage is the guarantee of protection against the risk of a particular event and is categorized and provided in accordance with the type of insurance hired. For the automobile sector, there are six types of coverage: vehicle damage, full claim, third-party damage, passenger damage, civil responsibility, and additional. For the whole insurance market we have hundreds of types of coverage provided in the 95 lines sold in Brazil.

To cite one insurance firm, according to the *Valor Econômico* newspaper on November 7<sup>th</sup> of 2017, BB Seguridade had a net profit of 1.2 billion in the third quarter of that year, showing the economic importance of the sector not only in terms of volume, but also growth rate, since this amount represented a 20.7% increase in comparison with the same period of 2016.

In the national and international literature, we find various studies of the insurance market. Shereden (1984) estimates the effects of price, income, and perception of risk over the demand for automobile insurance in 359 cities in the state of Massachusetts in 1979. He finds that demand is inelastic in relation to price and income and that the volume demanded increases substantially in areas with a greater population density. Khovidhunkit and Weiss (2005) study all the U.S. states, except Washington D.C., using panel data covering the period from 1982 to 1994. These authors find that demand is positively related with wealth, traffic density, and the number of registered automobiles; however, it is negatively related with price and the driver's age. Tipurić, Pejić, and Pavić (2008) analyze the evolution of concentration in the insurance market in countries in Central and Eastern Europe from 1998 to 2006. Besides finding a reduction in the degree of concentration, they show how the privatization of market leaders brought benefits and increased the demand for insurance. Central Europe and Eastern Europe have drawn special attention due to the opening up of private investments in this

sector. Škufljić, Galetić, and Gregurić (2011) analyze the time series evolution of three insurance market concentration indices [Herfindahl-Hirschman (HHI), CR4, and Gini indices] in Croatia for the period from 1998 to 2010 and conclude that there is a tendency for the concentration of this market to decrease in the following periods. Finally, Sharku and Shehu (2016) study the evolution of competition in the insurance market in Albania. With data from various insurance lines covering the period from 2005 to 2015, they show, using the CR1, CR4, and HHI concentration indices, that competition has increased in all, varying in intensity between the various insurance activities.

In the national literature, we also find various studies of the sector. Galiza (1998) presents a sample study covering 1995 to 1997, showing revenues, expenses, and the evolution of strategies of the companies in the sector. Ledo (2005) conducts an analysis of the inclusion of information asymmetry into the demand for insurance. Regarding the best usage of resources, Macedo, Silva, and Santos (2006) use data envelopment analysis techniques to analyze the efficiency of companies in the sector. Regarding the factors that influence the demand for automobile, equity, and life insurance, França Carvalho and Afonso (2010) test the effects of criminality and macroeconomic variables over the demand for automobile insurance in São Paulo in the period from 2003 to 2007, finding that criminality has an effect, with a delay in the insurance demand decision. Ledo (2011) goes beyond the insurance provider market and shows how the strategic behavior of insurance brokers can distort the mechanisms designed by the insurance companies. For São Paulo, in the period from January of 2002 to July of 2004, he showed that the rate of commission expected by the broker is negatively related with the premium required by the insurer. In his book, Figueiredo (2012) analyzes the insurance market in Brazil and its profitability. Finally, Freitas (2018) used data on the demand for automobile insurance in Rio de Janeiro in the first half of 2003 and found negative own price elasticities and positive crossed ones.

Given the importance of the sector, this article has two specific aims: to identify the degree of market concentration in the automobile segment and estimate the demand for automobile insurance, using as explanatory variables the insurance premium, the profitability of the sector, and the population's income level.

Market concentration will be analyzed by following the classic concentration indices used in industrial organization and using the annual sales volume (compiled from monthly data) of each insurance company in the period from 2001 to 2016. This period was chosen due to the availability of data and because it includes periods of internal and external economic turbulence, capturing possible changes in concentration resulting from this. To estimate the demand for insurance, we will use half-yearly data from 2002 to 2010 from the 27 federative

units (FUs) and, as explanatory variables, we will use the insurance premium, the company's profitability, and the consumer's disposable income. We will apply the panel data estimation method and its respective tests.

The article is composed of four sections, including this introduction. Section 2 presents the market concentration analysis for the automobile sector. Section 3 addresses the estimation of demand for automobile insurance and the data chosen for this estimation. In section 4, we conclude.

## 2. CONCENTRATION ANALYSIS OF THE AUTOMOBILE INSURANCE MARKET IN BRAZIL

Market concentration is one of the most relevant aspects when the objective is to evaluate anticompetitive behaviors or the formation of implicit or explicit cartels. These behaviors usually raise the prices of products or services, thus reducing consumer well-being; in these cases, the presence of regulation becomes necessary.

The concentration in the market may be influenced by structures in adjacent markets. For example, the insurance market is strongly influenced by the banking sector, in which recent mergers and acquisitions have caused even greater concentration (ABN Real and Santander, Itaú and Unibanco, Banco do Brasil and Nossa Caixa). After 1994, the financial sector (in particular, banking) showed an increase in concentration, as analyzed by Silva and Moraes (2006). Proner (2011) makes a comparison of this concentration in 2007 and 2010 to verify the effect of the global crisis over the Brazilian market. If, on one hand, the increase in banking concentration can generate greater reliability for depositors, on the other hand it makes the economy weaker in facing crises, as verified by Beck, Demirgüç-Kunt, and Levine (2006).

In this section, we will analyze the level of concentration in the automobile insurance market, using annual data for the period from 2001 to 2016 on the premium received by each insurer. These data are provided with monthly frequency by the Superintendence of Private Insurance (Susep) on its website in the Market Statistics area.

We will analyze six indices from the literature on industrial organization to assess the level of concentration in this market. A detailed description can be found in Pisanie (2013). To present them, we will suppose there are  $N \geq 2$  companies in the market and that each one has a share of the industry's supply given by  $s_i$ ,  $i = 1, 2, \dots, N$ ; this share is defined as the supply of company  $i$  divided by the total supply of the industry. To meet the specifications of all the indices, we will suppose that  $s_1 \geq s_2 \geq \dots \geq s_N$ . We can thus define the concentration indices below:

- a. Herfindahl-Hirschman Index (HHI) – Proposed by Herfindahl (1950) and Hirschman (1945), it is calculated as the sum of the squares of the companies' shares of market supply. The formula is:

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

Its value varies between 1 when the market is totally concentrated and  $1/N$  for the case of uniform distribution of supply.

- b. Comprehensive concentration index (CCI) – Also known as the Horvath index (Horvath 1970), it includes an additional weight  $(2 - s_i)$  for firms with a smaller market share, making their value more homogenous. The formula is given by:

$$CCI = s_1 + \sum_{i=2}^N s_i^2 (2 - s_i)$$

Its maximum value is 1 when we have a monopoly, and Marfels (1971) showed that its minimum value depends on the number of participants and is equal to  $(3N^2 - 3N + 1)/N^3$ . As the number of participants increases, making this market more competitive, the minimum value tends towards 0.

- c. Rosenbluth or Hall and Tideman index (HTI) – This index weights each firm's market share by its order of magnitude in total supply.

$$HTI = \left[ \left( 2 \sum_{i=1}^N i s_i \right) - 1 \right]^{-1}$$

This index varies from 1 (total concentration) to  $1/N$  (uniform distribution of supply).

- d. Linda index (LI) – Besides measuring the degree of concentration, it seeks to describe a criterion for evaluating oligopolistic structures that may be present. This index was developed by Linda (1976) and Vankerkem (1995). According to Vankerkem (1995),

$$LI = \frac{1}{N(N-1)} \sum_{i=1}^{N-1} Q_i$$

In this formula,  $Q_i = [(N - i) \sum_{k=1}^i s_k] / [i \sum_{k=i+1}^N s_k]$ ; that is, the ratio between the average share of the  $i$  biggest companies and the average share of the  $N - i$  smallest. Note that, if there is an oligopoly,  $Q_i$  increases with  $i$ , and then it decreases (when firms that do not belong to the oligopoly start to be included). This index has its lowest value when the distribution of supply is uniform and, in this case,  $LI = 1/N$ . The difference from the other indices is that, as the market approaches to a monopoly, it will take unbounded values.

- e. Gini coefficient (GC) – Proposed by Gini (1912), and originally used to measure income inequality, it is also used in various studies to measure inequality in exports, production, and the availability of services, since a high concentration implies greater inequality. In our case, the index is given by:

$$GC = 1 - \frac{1}{N} \sum_{k=1}^N s_i(2i - 1)$$

With a uniform distribution of market supply, the Gini index is 0; with total concentration, it is  $1 - N^{-1}$ , which gets closer to 1 as the number of firms increases.

- f. Hannah and Kay  $\alpha$  index [HK( $\alpha$ )] – Using each company's share and a parameter  $\alpha > 0$  and  $\alpha \neq 1$ , the HK( $\alpha$ ) is calculated by the following formula:

$$HK(\alpha) = \left[ \sum_{i=1}^N s_i^\alpha \right]^{\frac{1}{\alpha-1}}$$

This index takes the value 1 in the case of total concentration (monopoly) and its minimum value is  $1/N$  in the case of  $\alpha > 1$ . Note that  $HK(2) = HHI$ , and if we suppose  $\alpha > 2$  we will be increasing the curvature of the index, more easily capturing deviations from the uniform distribution of supply.

We aggregate the monthly data on premiums paid to the automobile insurers provided by Susep to obtain annual supplies. This way, we construct the concentration indices described and analyze their evolution for the whole period. Figure 1 shows the evolution of these indices in the period from 2001 to 2016.

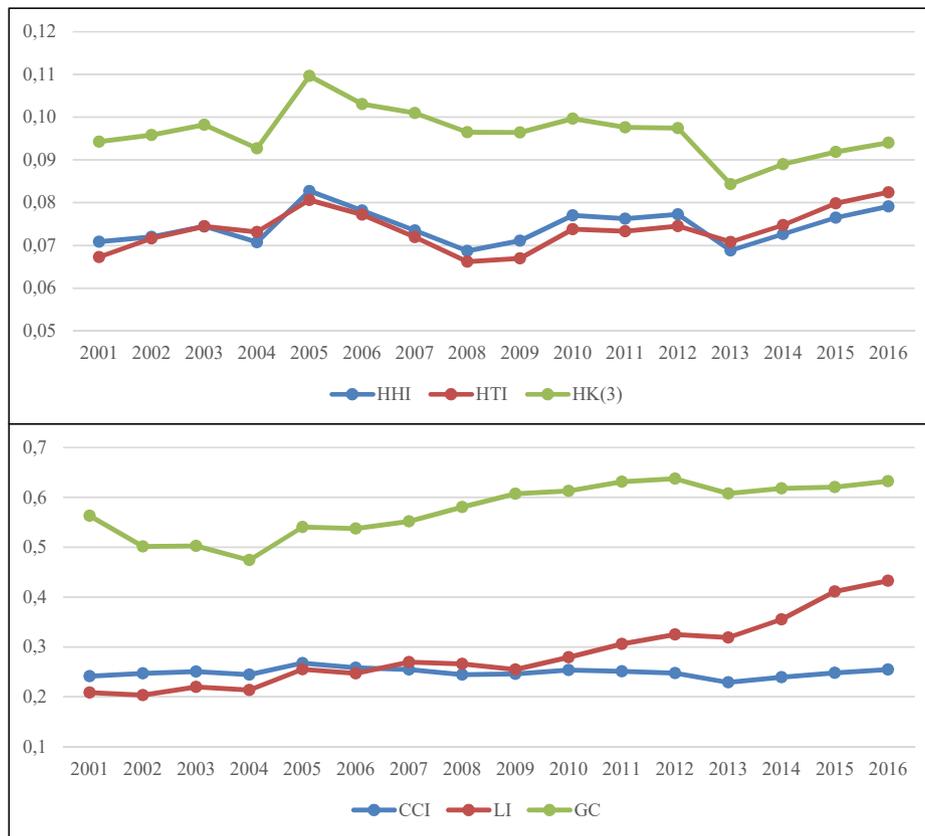


Figure 1 Evolution of the Brazilian automobile insurance market concentration indices. 2001-2016 period

CCI = comprehensive concentration index; GC = Gini coefficient; HHI = Herfindahl-Hirschman index; HTI = Hall and Tideman index; HK = Hannah and Kay index; LI = Linda index.

Source: Elaborated by the authors.

The number of companies that provide automobile insurance and that are registered in the Susep database varies from year to year. In the period analyzed, this number varies between 100 and 120 firms. However, approximately 30% provide 95% of the total premium traded each year. For this reason we consider, as a cut-off point, the biggest firms that in total supply 95% of the insurance (premiums) each year. We find that

between 26 and 38 firms were responsible for this supply. Therefore, the mean number of firms responsible for 95% of the supply of automobile insurance in the period is  $N = 32.56$ . This will be the number that we will use to apply the perfect competition limit case in each one of the indices, as indicated in their descriptions. Table 1 shows the descriptive statistics of the indices in the 2001-2016 period.

**Table 1**

*Concentration indices summary statistics and limiting values between monopoly and perfect competition cases*

	HHI	CCI	HTI	LI	GC	HK(3)
Mean	0.074	0.249	0.074	0.285	0.576	0.096
Standard deviation	0.004	0.009	0.005	0.069	0.053	0.006
Median	0.074	0.248	0.074	0.268	0.594	0.096
Maximum	0.083	0.268	0.082	0.433	0.637	0.110
Minimum	0.069	0.229	0.066	0.203	0.474	0.084
Monopoly	1.000	1.000	1.000	Infinite	0.969	1.000
Perfect competition	0.031	0.089	0.031	0.031	0.000	0.031

*CCI = comprehensive concentration index; GC = Gini coefficient; HHI = Herfindahl-Hirschman index; HK = Hannah and Kay index; HTI = Hall and Tideman index; LI = Linda index.*

**Source:** *Elaborated by the authors.*

For the HHI, Resende (1994) proposes the following classification criterion:  $HHI \in ]0,0.01]$  indicates a highly competitive market, but if  $HHI \in ]0.01,0.15]$ , we have an indication that it is not concentrated, with a good level of competition. In the interval  $HHI \in ]0.15,0.25]$  there is concentration, but it is moderate. For values of  $HHI \in ]0.25,1.0]$ , the concentration is considered high. The mean value observed was 0.074, with values that range from 0.069 to 0.083, indicating a sector with little concentration.

For the mean number of firms in the period, the CCI that would correspond to the null concentration is 0.089 and, for total concentration, it is 1.0. In our analysis, the index has a mean value of 0.249 with a very small standard deviation (0.009), thus indicating little concentration.

The HTI corresponding to uniform distribution of supply between the firms in the industry is  $1/N = 0.031$  and for monopoly it is 1. The values of this index observed in the period vary between 0.066 and 0.082, with a standard deviation of 0.005, which enables us to conclude that the market does not have a relevant concentration.

The value of the LI has the disadvantage of belonging to an unlimited interval; this is between  $1/N = 0.031$  for the case of uniform distribution of shares and infinite for the case of a totally concentrated market. In this study, the values varied between 0.203 and 0.433, which indicates a market with little concentration, but what is most important is that the observed values of  $Q_i$  did not show

any accentuated growth, with sharp falls as the aggregate share increases, in all the years of the period. Based on this, we can affirm that there are also no indications of the existence of oligopolies.

With the mean value of  $N$  in the period, the  $GC \in [0,0.969]$  is 0 in the case of a uniform distribution of the supply of insurance and 0.969 for the case of a monopoly. In our case, the values fluctuate between 0.474 and 0.637, which may indicate a market with moderate concentration. This is the only indicator that does not show a low concentration.

Finally, we evaluate the  $HK(\alpha)$  index, with the parameter  $\alpha = 3$  to be able to apply a greater curvature to the shares from that applied by the HHI and observe the sensitivity of the index to the presence of little concentration. We note that, in relation to the HHI, the mean  $HK(3)$  in this period is 0.096, which still represents a value close to the HHI and corresponds to little concentration.

Thus, from the results described, we can conclude that the automobile insurance market in Brazil did not present signs of concentration in the supply in the period from 2001 to 2016, more resembling perfect competition or one with little concentration.

Using this approach, it is perceived that these insurance companies in the automobile market act with similar intensity in this area, although they are competitors with each other. When, in a market, the generation of the service or supply of the product is spread between

various independent firms in terms of the control of some over others, without the existence of concentration, so that none can have any perceivable influence over the price level, perfect (or almost perfect) competition can be assumed. Stigler (1983) shows that, in general, for a market to be considered competitive, the following conditions are necessary:

- a. Numerous participants in the market, both on the supply side and on the demand side, none of which are able to take a considerable slice of the market in relation to the rest;
- b. Impersonal competition between the participants in the market and absence of power for any of them to be able to influence its behavior;
- c. The participants should have perfect knowledge of the market with regard to prices, to the quantity and the quality of the goods they wish to trade, and to the technology.

For Leite and Santana (1998), if lack of competition ensures the guarantee of obtaining greater profits, on the other hand it affects the efficiency of resources allocation. The same situation can occur in relation to organizational and administrative efficiency. Authors discuss the level of concentration influencing intersector relations, in an

industry of capital goods with an oligopolistic structure, analyzing how the high concentration will affect its prices, which in turn will affect prices and production processes in other industries, if these are consumers of goods from the first industry. Among some of the factors that contribute to an increase in the degree of concentration, Leite and Santana (1998) highlight internal growth of the firms, mergers, joint ventures, a reduction or increase in the market for a particular good, technological development, and governmental policies. In an industry in which a high concentration is verified, there is also greater inequality related to the size of the companies. Such a high concentration was not perceived or identified in the Brazilian automobile insurance market.

It is worth highlighting the comments from Davis and Garcés (2009) with respect to the analysis of the concentration indices. For them, concentration indices are market structure indicators that serve as a first analysis of industrial conduct and its performance. Yet, these are not determinants for concluding the competition regime. Sutton (1991, 1998) affirms that prices are dependent on the market structure when decisions are made in a game of two stages (initial entry decision and then decision to compete in some degree or to collude). The level of response of the firms to changes in demand conditions can provide information about their market power.

### 3. ESTIMATION OF THE DEMAND FOR AUTOMOBILE INSURANCE

In this section we will carry out the estimation of the demand for automobile insurance in Brazil. Given that the sector behaves in a way that is close to perfect competition, as assessed in section 2, the analysis of this demand will be carried out supposing that the premium paid by the insured party is close to the probability of a claim. Next, we explain the economic basis for this demand.

Consumers make their insurance acquisition decisions by evaluating the expected utility their wealth at the end of the period. This final value depends on the current value (related with current income), on the value that is exposed to risk, on the price of insurance, and on the probability of occurrence of a claim for the item insured. The rational consumer insures part or all of the value at risk. In practice, consumers can acquire insurance to cover the value at risk or even a little more.

For example, in vehicle insurance for 0 km cars, it is possible to insure up to 110% of the value of the vehicle and, thus, guarantee purchasing power in the event of a claim.

Specifically, suppose that the insured party has a wealth  $W_0$  that can suffer a loss  $L \in [0, W_0]$  with probability  $\pi \in [0, 1]$ . If the insurer offers insurance with a premium  $c \in [0, 1]$  (the price of each monetary unit insured), at what value will be insured by the client? Let  $l \in [0, L]$  be the part of the total potential loss that is insured; if the expected utility of the insured party is  $u(z)$ , then he will choose  $l$  by resolving:

$$\max_{l \in [0, L]} \pi u(W_0 - L + l - cl) + (1 - \pi)u(W_0 - cl)$$

The first order condition for an interior solution is:

$$(1 - c)\pi u'(W_0 - L + (1 - c)l) - c(1 - \pi)u'(W_0 - cl) = 0 \quad \boxed{1}$$

In a totally competitive environment and ignoring administrative costs, firms set, as a premium value, the marginal cost, that is, the probability of a claim,  $c = \pi$ , which means that the insured party buys the total insurance. As the

analysis in the previous section showed that competition is close to perfect competition, we consider that  $c = (1 + \gamma)\pi$ , that is,  $\pi = (1 + \gamma)^{-1}c$ , in which  $\gamma$  is the firm's mark-up or profitability factor. Substituting in equation 1:

$$(1 - c)(1 + \gamma)^{-1}u'(W_0 - L + (1 - c)l) - (1 - (1 + \gamma)^{-1}c)u'(W_0 - cl) = 0 \tag{2}$$

Thus, resolving equation 2, we will have the demand for insurance given by:

$$l = l(c, \gamma, W_0, L) \tag{3}$$

In general, equation 2 implicitly defines the insured amount  $l$  as a function of the price of the insurance  $c$ , of the profitability factor  $\gamma$ , of the individual's wealth  $W_0$ , and of the value at risk  $L$ , which is non-observable. In Annex A, we explicitly calculate the amount insured in function of these other variables for the case of a constant relative risk aversion (CRRA) utility function and we illustrate how, even in this specific case, the sign of the response

of  $l$  to changes in  $c$  and in  $\gamma$  is undetermined and with respect to  $W_0$ , has little significance. For this reason, we need an empirical analysis that determines these signs and their magnitudes.

As we have unobserved variables in the model (e.g. the value at risk  $L$ ), which besides being specific for each individual can vary over time, we will include these components in the econometric model. This model is known in the literature as a two-way error component model. In these terms, the log-linearized equation of the demand for automobile insurance is given by:

$$\ln(amt)_{i,t} = \beta_0 + \beta_1 \ln(pre)_{i,t} + \beta_2 \ln(rtn)_{i,t} + \beta_3 \ln(indv)_{i,t} + \alpha_i + \lambda_t + u_{i,t} \tag{4}$$

in which  $amt$  is the amount insured,  $pre$  is the premium per unit insured,  $rtn$  is the return per unit insured, and  $indv$  is the index of retail sales. The parameter  $\alpha_i$  represents the unobservable individual-specific effect,  $\lambda_t$  represents the unobservable time-specific effects, and  $u_{i,t}$  is the mean random term 0 and constant variance. For more details on this type of modeling, both from the static and dynamic viewpoints, see Baltagi (2005). Details of the process of log-linearizing of a function defined implicitly by an equation are in Annex B.

To obtain consistent estimates of the coefficients in equation 4, we use four estimators: pooled ordinary least squares (POLS), OLS for the transformed data, fixed effects (FE) and random effects (RE), and the generalized method of moments (GMM) estimator method, from Arellano and Bond (1991) (AB), for a dynamic panel. The variables used in the empirical model were calculated based on the data obtained in the statistical reports on the automobile sector at Susep. These variables are in half-yearly frequency from the first semester of 2002 to the second semester of 2010 (last semester made available by the institution) for

each FU of Brazil; that is, the individuals are aggregated by FU (26 states and the Federal District) over 18 semesters.

Table 2 presents some descriptive statistics (panel A) and the matrix of correlations between the variables used in the model (panel B). Based on this table it is possible to make inferences about the unconditional behavior of the variables. We can perceive, from panel A, that profitability ( $rtn$ ) is the only variable that presents excess kurtosis (fat tails) and asymmetry to the right, while the others present asymmetry to the left and platykurtosis (thin tails). Observing the coefficient of variation, we verify that the sales index has a greater variation in relation the mean than the other variables.

When we observe panel B, we perceive that, unconditionally, the premium and profitability are negatively related with the amount insured and the sales index is positively related to this, which seems to be intuitive. With respect to the first assertion, the premium and profitability of the firm are expected to be directly related whereas; in the latter, the more heated the economy, the greater the demand may be for insurance.

**Table 2**  
Summary statistics and correlations matrix

A – Summary statistics							
Variable	Mean	Standard deviation	Minimum	Maximum	Asymmetry	Kurtosis	Coefficient of variation
amt	13.3646	1.6084	9.5393	17.3973	-0.3160	2.5689	0.1203
pre	-8.5598	0.2253	-9.3150	-7.9321	-0.0375	2.4527	-0.0263
rtn	-4.6611	0.2262	-5.2727	-3.7840	0.7985	4.2467	-0.0485
indv	0.6997	0.1902	-0.0208	1.0536	-0.1655	1.7890	0.2718
B – Correlations matrix							
	amt	pre	rtn	indv			
amt	1.00	-	-	-			
pre	-0.22	1.00	-	-			
rtn	-0.47	0.59	1.00	-			
indv	0.17	-0.21	-0.35	1.00			

Source: Elaborated by the authors.

Returning to the econometric model, to the basic specification in equation 4 we add the first lag of the regressors, to verify the possibility of lagged effects over the amount insured. The abovementioned estimators are constructed in order to address the unobserved individual-

$$\ln(amt)_{i,t} = \beta_0 + \beta_1 \ln(pre)_{i,t} + \beta_{12} \ln(pre)_{i,t-1} + \beta_2 \ln(rtn)_{i,t} + \beta_{22} \ln(rtn)_{i,t-1} + \beta_3 \ln(indv)_{i,t} + \beta_{33} \ln(indv)_{i,t-1} + \alpha_i + \lambda_t^D + u_{i,t}$$

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As the processes for transforming the data in the FE and RE estimation may generate an autocorrelation (serial correlation) in their respective error terms, we also estimate a version of these estimators that takes into consideration that the errors are autoregressive to the order of 1. The estimations were carried out using routines and standard packages of the Stata 15 software.

Table 3 shows the estimates for the parameters in equation 5. The statistical significance of the Hausman (1978) test indicates the appropriate FE estimator for our problem, which suggests that the individual-specific effect is correlated with at least one explanatory variable in

specific effects automatically (except POLS, which is biased and inconsistent, in this case). To address the time-specific effect, we include half-yearly time dummies ( $\lambda_t^D$ ), taking as a reference the first semester of 2002. So, we can represent the first equation to be estimated by

the model. This conclusion is plausible, since the wealth exposed to risk  $L$ , an unobservable variable in our model, is expected to be correlated with the premium paid by the insured party. Since we cannot reject the hypothesis of the existence of an individual-specific effect in the model, the POLS estimator is biased and inconsistent.

With respect to the time-specific effect, the p-value of the joint significance test of the time dummies, represented by  $D\_joint$  in Table 2, indicates the rejection of the null hypothesis, i.e., the dummies are jointly statistically different from 0, so the time-specific effect is significant.

**Table 3**  
Parameters estimates for the equation 5

Variable	POLS	FE	RE	FE-AR(1)	RE-AR(1)
ln(pre)	-0.799 (-1.28)	<b>-0.334*</b> <b>(-2.02)</b>	-0.352* (-2.05)	<b>-0.431***</b> <b>(-3.51)</b>	-0.456** (-3.06)
ln(pre) <sub>t-1</sub>	-0.502 (-0.46)	-0.00704 (-0.04)	-0.0266 (-0.15)	-0.105 (-0.86)	-0.0944 (-0.65)
ln(indv)	-1.554 (-1.82)	-0.0595 (-0.29)	-0.0651 (-0.31)	-0.149 (-1.00)	0.268* (2.13)
ln(indv) <sub>t-1</sub>	2.391** (2.96)	<b>0.482*</b> <b>(2.33)</b>	0.503* (2.33)	0.0142 (0.09)	0.171 (0.99)
ln(rtn)	-3.058*** (-4.52)	-0.00912 (-0.10)	-0.0278 (-0.29)	0.0242 (0.34)	-0.0319 (-0.38)
ln(rtn) <sub>t-1</sub>	-3.676*** (-6.72)	<b>-0.269**</b> <b>(-2.92)</b>	-0.291** (-3.03)	-0.127 (-1.75)	-0.205* (-2.36)
Constant	-28.57* (-2.57)	8.686*** (5.89)	8.177*** (5.30)	7.952*** (11.56)	7.098*** (3.88)
D_joint	0.000***	0.000***	0.000***	0.000***	0.000***
Hausman	-	41.05 (0.000***)		341.07 (0.000***)	

**Note:** (robust) *t* statistic in parentheses.  $D\_joint$  is the *p*-value of the joint significance test for the time dummies  $\lambda_t^D$  [for the fixed effects (FE) estimators, the Fischer *F* statistic, and for the random effects (RE) estimators, the chi-squared statistic]. Hausman are the test statistics and *p*-value in parentheses of the Hausman test. Values in bold are the results that worth to highlight.

POLS = pooled ordinary least squares.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

**Source:** Elaborated by the authors.

More attentively observing the results of the FE estimators and FE-AR(1), FE without and with AR(1) errors, in columns 3 and 5 of Table 2, respectively, we can see that both specifications indicate that the elasticity

of the amount insured in relation to the premium is statistically significant. As the value of this elasticity is negative, the higher the insurance premium, the lower the amount insured, i.e., the lower the demand for insurance.

In the FE-AR(1) model, only the coefficient of the premium variable was statistically significant, with an absolute value 22.5% greater than in the FE model; however they are not statistically different among each other (the confidence intervals for these estimators overlap). The FE model also indicated as statistically significant the coefficients for the sales index and profitability variables,

$$\ln(amt)_{i,t} = \beta_0 + \rho \ln(amt)_{i,t-1} + \beta_1 \ln(pre)_{i,t} + \beta_{12} \ln(pre)_{i,t-1} + \beta_2 \ln(rtn)_{i,t} + \beta_{22} \ln(rtn)_{i,t-1} + \beta_3 \ln(indv)_{i,t} + \beta_{33} \ln(indv)_{i,t-1} + \alpha_i + \lambda_t^p + u_{i,t}$$

6

The main problem with our FE estimator is that it becomes biased with the inclusion of the lagged dependent variable. To address this problem, we will use the AB estimator for dynamic panels. Table 4 shows the estimated parameters both for the FE model, whose estimator for the lagged dependent variable is biased, and for different specifications for the AB estimator. In the specifications

both lagged by one period. These differences between the coefficients and the existence of a residual correlation in both models suggest a possible adjustment dynamic of the dependent variable that is not considered in equation 5.

To evaluate this hypothesis, we include the amount insured,  $\ln(amt)$ , lagged by one period in our specification in equation 5. In this case we have:

of AB1 to AB4, the difference is only in the number of instruments used. In the ABF specification, we use the first forward difference with the same number of AB1 instruments. We estimate various specifications for the AB estimator with different quantities of instruments. The results were not significantly different from those presented in Table 4.

**Table 4**  
*Parameters estimates for the equation 6*

Variable	FE	AB1	ABF	AB2	AB3	AB4
$\ln(amt)_{t-1}$	0.761*** (7.03)	<b>0.659***</b> <b>(8.61)</b>	<b>0.682***</b> <b>(8.81)</b>	<b>0.616***</b> <b>(8.67)</b>	<b>0.608***</b> <b>(9.20)</b>	<b>0.561***</b> <b>(12.73)</b>
$\ln(pre)$	-0.458** (-3.05)	<b>-0.505**</b> <b>(-3.45)</b>	<b>-0.445**</b> <b>(-2.99)</b>	<b>-0.470**</b> <b>(-3.25)</b>	<b>-0.478**</b> <b>(-3.27)</b>	<b>-0.459**</b> <b>(-3.01)</b>
$\ln(pre)_{t-1}$	0.246 (1.47)	0.173 (0.77)	0.220 (1.33)	0.165 (0.83)	0.159 (0.81)	0.162 (0.83)
$\ln(indv)$	-0.137 (-0.92)	-0.178 (-1.13)	-0.129 (-0.88)	-0.251 (-1.59)	-0.244 (-1.81)	-0.238 (-1.89)
$\ln(indv)_{t-1}$	0.0787 (0.46)	0.0472 (0.28)	0.120 (0.73)	-0.00573 (-0.03)	0.00153 (0.01)	0.0118 (0.06)
$\ln(rtn)$	0.0631 (0.75)	-0.00999 (-0.14)	0.0556 (0.66)	-0.0489 (-0.76)	-0.0465 (-0.66)	-0.0628 (-0.83)
$\ln(rtn)_{t-1}$	-0.155* (-2.73)	<b>-0.204**</b> <b>(-3.14)</b>	<b>-0.167**</b> <b>(-2.89)</b>	<b>-0.246**</b> <b>(-3.54)</b>	<b>-0.236**</b> <b>(-3.40)</b>	<b>-0.245**</b> <b>(-3.62)</b>
D_joint	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
# of Inst.	-	158	158	132	121	106
AR(2)	-	0.912	0.843	0.955	0.962	0.987
Hansen	-	0.998	0.997	0.998	0.997	0.997

**Note:** *t* statistic in parentheses. D\_joint is the p-value of the joint significance test for the time dummies. Hansen is the p-value of the Hansen overidentifying restrictions test. # of Inst. is the number of instruments in each model. Values in bold are the results that worth to highlight.

AB = Arellano and Bond method; FE = fixed effects.

**Source:** Elaborated by the authors.

We can observe that the time-specific effect is relevant, as the significance of the D\_joint statistic indicates. The residual autocorrelation was not significant, since the AR(2) test for second order autocorrelation was not significant and the Hansen test indicates in favor of the validity of the overidentifying restrictions. These results repeat for all the specifications used, indicating that the estimates are robust to the specification.

The lagged dependent variable was statistically significant and indicates persistence in the amount insured

above 0.56 from one period to the next. That is, more than 56% of the amount insured in the previous period will, on average, continue being insured in the following period. The mean value of the estimates of this parameter, including those not reported, was 0.58. In addition, all the confidence intervals for these variables overlap, suggesting that the parameters estimated in each specification are not different from each other.

The premium variable was statistically significant and corroborates the result found previously, i.e., the demand

for insurance is negatively related with the premium. The mean value of the estimated coefficient was -0.47. As our specifications are log-linear, this coefficient represents the price-elasticity of the demand for insurance in the short term, that is, the short-term sensitivity of the demand for insurance in relation to the premium charged. Since the absolute value of this elasticity is statistically lower than 1, we can conclude that the demand for automobile insurance in Brazil is inelastic in the short term.

In the long term, when prices (premiums) and quantities (amounts insured) stabilize (that is  $pre_t = pre_{t-1}$ , and  $amt_t = amt_{t-1}$ ), we will obtain, based on equation 6, as the long-term price-elasticity of the demand the value of  $(\beta_1 + \beta_{12}) / (1 - \rho)$ . As  $\beta_{12}$  is not significant and the mean value of  $\rho$  is 0.625, the long-term price-demand elasticity for insurance is -1.33; that is, the demand for insurance becomes elastic in the long term.

#### 4. CONCLUSION

The structure of the Brazilian insurance market is extremely important for understanding the behavior of the firms that compose it, as well as for understanding its contribution to the country's economic activity. In this paper, we analyzed the automobile insurance market in Brazil and revealed its low concentration by analyzing the classic concentration indices from the literature.

Market concentration has various causes, among which can be mentioned the ease of mergers and acquisitions in markets that present firms with high profitability and synergy, the barriers to entry that some sectors can present, and the high costs in initial investments. The consequences are the presence of inefficient market prices, difficulty in its regulation, externalities on the power of adjacent markets, and high profitability levels. Non-concentration brings a more efficient price system to the economy, leading to competition and sustained and balanced growth. Currently, despite being clearly noticeable, the great interest of life insurers in offering more personalized products to certain publics, such as life insurance for diabetics or specific products for women, as well as services for certain insured party profiles, such as ones created for those who practice radical sports, automobile insurance remains important and expressive of this market. In a wide range of insurance sectors, partnerships have also emerged between companies in the segment, which has helped insurers to reach a greater number of clients

Finally, it is interesting to note that the effect of the lagged profit over the current demand for automobile insurance is negative. This means that a fall (or abdication) of profit by 1% in one period leads to an 0.21% increase in the demand for insurance in the following period (in the long term this effect is 0.59%), which can be explained by many reasons. When the company (or the industry) experiences a fall in profits (whether due to a fall in purchasing power or due to some external shock), it concentrates efforts on recovery through advertising campaigns, complementary products, or ease of payment, providing greater availability for clients to acquire insurance. Reciprocally, extraordinary increases in profits tend to reduce the companies' efforts to provide these complementary products or facilities, meaning the demand for insurance naturally tends to be lower.

than that obtained by any traditional insurance network, independently of its size or capillarity. However, even with these factors and with the high regulation of insurers, the other insurance lines may have different and even antagonistic structures from the one presented here.

This article also sought to analyze the behavior of the demand for automobile insurance considering the influence of three variables: the premium (or price of insurance), the consumer's income, and the company's profitability. For this, we used data from all the Brazilian states and the Federal District provided by Susep. One of the weaknesses of this study lies in the fact that the period analyzed, 2001 to 2006, could be considered short compared to the cross-sectional dimension (number of states). However, the results obtained with specific tests for this situation are consistent. The data series with the information used is half-yearly and covers around 486 pooled panel data observations. The results show a price elasticity of the demand for automobile insurance equal to -0.47 and an elasticity of this same demand in relation to the lagged profitability equal to -0.21, in the short term, and -1.33 and -0.59, respectively, in the long term; both values are coherent with the individual behavior of the economic units involved. The income elasticity of the demand was insignificant; however this could be improved, using some more suitable proxy for this independent variable.

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## ANNEX A

Calculation of the demand for insurance in the case of constant relative risk aversion (CRRA) utility

We will calculate, explicitly, the demand for insurance in the case of the individual having a CRRA-type expected utility function. Substituting  $(z) = \frac{z^{1-\theta}}{1-\theta}$ ,  $\theta \geq 0$ , in equation 2 we have:

$$\begin{aligned} \left( \frac{W_0 - L + (1-c)l}{W_0 - cl} \right)^{-\theta} &= \frac{c(1-\pi)}{\pi(1-c)} \Rightarrow \frac{W_0 - L + (1-c)l}{W_0 - cl} = \left( \frac{\pi(1-c)}{c(1-\pi)} \right)^{\frac{1}{\theta}} \equiv M \\ \Rightarrow l &= \left( \frac{1}{1-c(1-M)} \right) L - \left( \frac{1-M}{1-c(1-M)} \right) W_0 \end{aligned}$$

As  $\pi = c(1+\gamma)^{-1}$ , then  $M = M(c, \gamma)$ , therefore, from this equation we explicitly have  $l = l(c, \gamma, W_0, L)$ , just as in equation 3. Note that, as  $c > \pi$ , then  $0 < M < 1$ , but now we can make the analysis of the sign of the variation in  $l$  in relation to the variables  $(c, \gamma, W_0, L)$ . First, we have:

$$\begin{aligned} M^\theta &= \frac{\pi(1-c)}{c(1-\pi)} = (1+\gamma)^{-1} \left( \frac{1-c}{1-c(1+\gamma)^{-1}} \right) \\ \Rightarrow \theta \ln M &= -\ln(1+\gamma) + \ln(1-c) - \ln(1-c(1+\gamma)^{-1}) \end{aligned}$$

Denoting for  $M_i$ ,  $i = c, \gamma$ , the partial derivative of  $M$  in relation to  $i$  will be:

$$\begin{aligned} \theta \frac{M_c}{M} &= -\frac{1}{1-c} + \frac{(1+\gamma)^{-1}}{1-c(1+\gamma)^{-1}} = \frac{(1+\gamma)^{-1} - 1}{(1-c)(1-c(1+\gamma)^{-1})} < 0 \\ \theta \frac{M_\gamma}{M} &= -\frac{1}{1+\gamma} - \frac{c(1+\gamma)^{-2}}{1-c(1+\gamma)^{-1}} = -\frac{1}{(1-c)(1-c(1+\gamma)^{-1})} < 0 \end{aligned}$$

Therefore:

$$\frac{\partial l}{\partial c} = \frac{(1-M) - cM_c}{(1-c(1-M))^2} L - \frac{(1-M)^2 - M_c}{(1-c(1-M))^2} W_0$$

As  $c > \pi$ , then  $M < 1$ ; thus, the coefficient of  $L$  in this expression is positive, but the coefficient of  $W_0$  is negative [since  $(1-M)^2 - M_c > 0$ ]; therefore, the sign of  $\partial l / \partial c$  is undetermined, since it will depend on the magnitude of these coefficients and on  $L$  and  $W_0$ . Similarly:

$$\frac{\partial l}{\partial \gamma} = \frac{\partial l}{\partial c} \frac{dc}{d\gamma} = \pi \left( \frac{(1-M) - cM_c}{(1-c(1-M))^2} L - \frac{(1-M)^2 - M_c}{(1-c(1-M))^2} W_0 \right)$$

Therefore, with an undetermined sign as well. Finally:

$$\frac{\partial l}{\partial W_0} = -\left( \frac{1-M}{1-c(1-M)} \right) < 0 \text{ e } \frac{\partial l}{\partial L} = \left( \frac{1}{1-c(1-M)} \right) > 0$$

since  $0 < M < 1$  and  $0 < c < 1$ . In any case, as  $c$  is close to  $\pi$  due to the competition, the value of  $M$  is close to 1 and the sign of  $\frac{\partial l}{\partial W_0}$  may not be very significant. Thus, the response of  $l$  to variations in  $c$  and  $\gamma$  is undetermined and, in relation to  $W_0$ , it is not very significant.

## ANNEX B

### Log-linearization

Suppose that the equation  $(x, y) = 0$  is satisfied in  $(x_0, y_0)$ ,  $y_0 \neq 0$  and  $F_2(x_0, y_0) \neq 0$ . Define  $G(u, v) = F(e^u, e^v)$ , in which  $u = \ln x$  and  $v = \ln y$ . So, the linear approximation of the equation  $(u, v) = 0$  in a neighborhood of  $(u_0, v_0) = (\ln x_0, \ln y_0)$  is:

$$\begin{aligned} G(u_0, v_0) + G_1(u_0, v_0)(u - u_0) + G_2(u_0, v_0)(v - v_0) &= 0 \\ \Rightarrow F(e^{\ln x_0}, e^{\ln y_0}) + e^{\ln x_0} F_1(e^{\ln x_0}, e^{\ln y_0})(\ln x - \ln x_0) \\ + e^{\ln y_0} F_2(e^{\ln x_0}, e^{\ln y_0})(\ln y - \ln y_0) &= 0 \\ \Rightarrow x_0 F_1(x_0, y_0)(\ln x - \ln x_0) + y_0 F_2(x_0, y_0)(\ln y - \ln y_0) &= 0 \end{aligned}$$

As  $y_0 F_2(x_0, y_0) \neq 0$ , from the previous equation we can factorize  $\ln y$  and obtain:

$$\ln y = \beta_0 + \beta_1 \ln x$$

In this case we have equation 2, of the type  $F(c, \gamma, W_0, L, I) = 0$ , which with the hypothesis of non-singularity of  $IF_1(c, \gamma, W_0, L, I)$  will allow for this equation to be extended, obtaining equation 4 to be estimated.