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ORIGINAL ARTICLE

Side effects of the pandemic: impacts on the business interruption insurance market

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ABSTRACT

The aim of this article was to analyze the underwriting dynamics and coverage extent in business interruption insurance, investigating the probability updating process during the pandemic. While the impact of the pandemic on the business insurance market in Brazil has not been quantified, this study fills that gap by identifying the pandemic's effects on the business interruption line of business (LOB) and highlighting any policy reformulations. The relevance of this paper is examining how the insurance market perceives and reacts to unpredictable exogenous events, and offering insights into the behavior of economic agents under these conditions. The findings reveal that the pandemic significantly impacted the insurance market, particularly the business interruption LOB. This research provides behavioral evidence that could inform responses to future unexpected adverse events in the insurance sector. We used a two-stage panel data regressions, using official data from the Brazilian insurance market covering Jan/2003-Dec/2023, with a total of 25,333 observations from 180 insurers. The impact of the pandemic on underwriting decisions, premium collection, and claims within business interruption and other LOBs was estimated. During the pandemic, operations in the business interruption LOB and premium revenues showed a gradual decline. Initially, there was a 0.60% increase in claim payments, followed by a stabilization period. The pandemic's impact on the business interruption insurance market deviated from the overall insurance market trend. Evidence of the probability updating phenomenon was observed within this industry.

Keywords: insurance market, business interruption, pandemic.

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Efeitos colaterais da pandemia: impactos no mercado de seguros de lucros cessantes

RESUMO

Este artigo teve por objetivo analisar a dinâmica de subscrição e a extensão das coberturas de seguros de lucros cessantes, investigando o processo de atualização de probabilidades na pandemia. No Brasil, o impacto da pandemia sobre o mercado de seguros empresariais não havia sido quantificado. Este estudo permite identificar os efeitos do evento neste ramo e apontar eventuais reformulações nas apólices. A relevância desta pesquisa está em analisar a percepção do mercado segurador diante de eventos exógenos imprevisíveis e entender a reação dos agentes econômicos nessas condições. Os resultados mostram que a evolução da pandemia impactou o mercado de seguros de maneira relevante, em especial o ramo de lucros cessantes. Espera-se oferecer evidências de comportamento no mercado de seguros em ocorrências futuras de eventos adversos inesperados. Utilizam-se regressões para dados em painel em dois estágios, com dados oficiais do mercado segurador brasileiro, mensais entre jan/2003-nov/2023, usando 25.333 observações, de 180 empresas. Estimaram-se efeitos da pandemia sobre a decisão de subscrição e nos prêmios de lucros cessantes, e sobre todos os demais ramos. Repetiu-se o procedimento para as indenizações. Durante a pandemia, a operação no ramo de lucros cessantes e o volume de prêmios arrecadados diminuíram gradativamente. Concomitantemente, verificou-se um incremento inicial de 0,60% no pagamento de sinistros, com posterior estabilização. Ademais, os impactos da pandemia sobre o mercado de seguros de lucros cessantes são distintos do padrão do mercado de seguros como um todo. Há evidências do fenômeno de atualização de probabilidade neste setor.

Palavras-chave: *mercado de seguros, lucros cessantes, COVID-19.*

1. INTRODUCTION

The COVID-19 pandemic, which emerged in 2020, is considered an extraordinarily rare and high-severity event that has had far-reaching consequences, not only in terms of health but also in economic terms, with impacts whose full extent remains uncertain (Li et al., 2021). While the effects of the pandemic continue to reverberate, there are indications that the spread of the disease is beginning to slow (World Health Organization [WHO], 2021).

The social distancing measures imposed to curb the spread of the virus led to a sharp contraction in certain economic sectors and, consequently, immediate production losses (Jackson et al., 2020). Some industries, deemed "non-essential," were entirely suspended during intermittent lockdowns enforced by health and governmental authorities. Even those classified as "essential" saw a reduction in demand. As a result, the economic shock caused by the pandemic contributed to some companies declaring bankruptcy (Aurélio & Coelho, 2021).

In this environment of uncertainty, pessimistic expectations dominated the economic outlook (Pellegrino et al., 2021). These negative forecasts played a key role, prompting many businesses to turn to insurers for support, hoping to mitigate potential financial setbacks through coverage for so-called business interruption losses (Klein & Weston, 2020). For businesses, this coverage pertains to the loss of production and revenue, directly resulting from the damaging event. This type of insurance is triggered when the damage is caused by circumstances outlined in the policy that lead to property losses for the company. With this coverage in place, it is anticipated that the insured will receive compensation sufficient to restore the business to its pre-loss status (Paradine, 1995).

Despite existing regulations on the matter, there is no legal consensus on the limits of their applicability. With the onset of the pandemic and the cessation of profits due to business interruptions, many companies whose policies were already in force invoked the force majeure doctrine to seek contract revisions (Sabrinni & Póvoa, 2021). In addition to the demand for coverage under existing policies, there is also evidence of an increased interest in acquiring this type of coverage (Bisco et al., 2020).

However, the mass payment of such compensation could pose a significant threat to the financial solvency of insurers (C. C. French, 2020). The literature documents the crucial role the insurance industry plays in social protection, but it is also often seen as a source of systemic risk (Carvalho & Guimarães, 2024; Eling & Pankoke, 2016; Kaserer & Klein, 2019). Insurers, after all, anticipate harmful events and estimate future compensation based on present value to offer coverage (Euphasio Junior & Carvalho, 2022). Insurable risk refers to an event marked by uncertainty, futurity, and potential harm to the insured's interests. The uncertainty surrounding

the risk can be defined as a state linked to a small but measurable probability of a claim occurring. This risk must be financially quantifiable, likely to materialize through the claim, and its uncertainty can be modeled using a probability distribution (Vaughan & Vaughan, 2013).

The objective of this study is to analyze the dynamics of the business interruption insurance market in Brazil, focusing on both policies in force prior to the pandemic and those issued afterward. The study aims to quantify insurers' propensity to underwrite policies in this segment, as well as to assess the volume of premium collection and claims payments associated with the business interruption clause, by comparing these figures to the pre-pandemic period. This research is particularly relevant, as the time that has passed since the onset of the pandemic provides an opportunity to capture the effects of probability updating through changes in policy underwriting dynamics (Fier et al., 2015). Consequently, it offers a clearer understanding of the economic impacts and the reactions – including legal ones – linked to this issue.

2. THEORETICAL BACKGROUND

Conceptually, insurance is a contractual arrangement between private parties, grounded in risk and uncertainty. The primary purpose of such contracts is to protect individuals or entities within society who may be vulnerable to certain insurable risks (Varian, 2015). One of the core principles of insurance is mutualism, where, through a loss-sharing agreement, the economic burden of a common insurable risk is distributed among a specific group of individuals exposed to that risk (Vaughan & Vaughan, 2013).

Insurance typically provides coverage for tangible, replaceable assets, with the value of the contract tied directly to the insured asset. Premiums are determined based on the probability of losses and the expected severity of those losses. However, when it comes to business enterprises, a different type of loss can occur. If profits generated from the use of the property are not realized, leading to an interruption in operational cash flow, a new method for measuring economic loss is required. This expectation of unrealized profits is known as business interruption losses. Circular no. 620/20, issued by the Superintendence of Private Insurance (SUSEP), defines this type of coverage as follows:

> Article 8. Business interruption insurance aims to ensure compensation for losses resulting from the partial or total interruption or disruption of the insured's business operations, caused by the occurrence of risks covered in the policy, not limited to property risks. Unique Paragraph. The contractual conditions must establish the criteria for characterizing and determining the losses.

In Brazil's legal framework, it is provided for in Article 402 of the Civil Code, *in verbis*.

> Article 402. Save for exceptions expressly provided by law, the damages owed to the creditor include**, in addition to what was actually lost, what was reasonably not earned**. (*emphasis added*)

Historically, business interruption insurance has been linked to property damage (Borghesi, 1993). However, there are specific characteristics that distinguish this type of coverage. First, the business interruption insurance clause is an add-on, meaning it can only be activated if there is a primary insurance policy in place. As an ancillary coverage, it applies only if specified in the contract. For the coverage to be valid in the event of a claim, several conditions must be met: (i) the presence of physical damage, (ii) the insured property, (iii) the specific risk being covered in the contract, (iv) the resulting loss must be measurable, and (v) the coverage will only apply during the necessary period to restore the property damage. If any of these conditions are unmet, the coverage will not apply (Borghesi, 1993). According to SUSEP regulations, this insurance must be contracted with at least one of the following basic coverages: gross profit loss, net profit loss, gross revenue loss, fixed expenses, or contribution margin (i.e., the difference between sales revenue and its direct variable costs) (Nogueira Junior, 2013).

Despite the need for detailed contractual provisions in business interruption coverage, legal disputes on this matter are common, not only in Brazil but also globally. The ambiguity in contract language, the use of vague terms, and the lack of a standardized formula for assessing losses when business interruption insurance is triggered make it difficult to reach consistent court rulings. In catastrophic events, such differences of opinion are not unusual. For instance, disputes arose after Hurricane Katrina (2005), the attacks on the World Trade Center in 2001 (C. French, 2013), and the SARS respiratory syndrome outbreak in 2003 (Ramnath, 2020). Similarly, the COVID-19 pandemic has sparked new debates and legal challenges (Louaas & Picard, 2023; Schmitt & Spaeter, 2023; Tereszkiewicz, 2023).

One of the key controversies revolves around property damage. From a conceptual standpoint, property damage is fundamental for triggering the issuance of business

interruption insurance. For instance, if a company halts operations due to vandalism, and the policy covers such events, the insurance should compensate for the resulting loss of profits. However, if the cessation of operations occurs due to a government mandate, as in the case of a pandemic, it becomes challenging to consider the situation as a valid business interruption, as there is no physical damage to the property (Ramnath, 2020).

In June 2020, the Financial Conduct Authority (FCA), the insurance regulator in the United Kingdom, initiated a legal case to clarify issues surrounding business interruption insurance in the context of the pandemic. This case, known as the "FCA Test Case," focused on claims related to additional coverages specifically contracted by policyholders, regardless of material damage—often referred to as non-damage covers. This practice, common in the UK but less so in Brazil, addresses situations where business interruption occurs without physical property damage. In this case, it was determined that business interruption policies linked solely to property damage would not cover losses arising from the COVID-19 pandemic. In other words, business interruption coverage contingent on material damage was not included in the FCA Test Case. This distinction was emphasized in the 2021 ruling, which authorized the payment of claims.

In Brazil, both basic and additional coverages typically require the occurrence of material damage, making non-damage covers, as addressed in the FCA Test Case, relatively uncommon. Using this ruling as a precedent would complicate the argument for the payment of business interruption claims, as there was no material damage caused by the government-imposed mandates during the COVID-19 pandemic. The suspension of business activities would not be directly linked to prior property damage, thereby limiting the scope of coverage under traditional Brazilian policies.

An alternative perspective, rooted in Brazilian legal jurisprudence, argues that the concept of property damage should not be taken literally. In Brazilian law, property damage includes the deprivation of the use of an asset, as established by legal scholars like Diniz (1995). This view is supported by higher courts, where deprivation of use is recognized as a form of damage, thus extending the notion of property damage to cover business interruption losses (Term, 2021). Therefore, unlike the UK approach, material damage in Brazil is not necessarily limited to physical harm but can also encompass situations where the asset's use is rendered impossible.

A key issue in the debate over business interruption compensation during the pandemic concerns the financial solvency of insurance companies. Recent studies (Halling et al., 2020; Hauser et al., 2021; Puławska, 2021) indicate that the COVID-19 pandemic negatively impacted the European financial sector. The closure of "non-essential" services in many European countries had adverse effects on the insurance industry, which in turn affected the broader economy. This highlights the crucial role insurers play in maintaining financial system stability (Harrington, 2009; Weiß & Mühlnickel, 2014).

For instance, the bankruptcy of American International Group (AIG) in 2008 (McDonald & Paulson, 2015) triggered widespread financial sector stress (Fonseca & Carvalho, 2025; Harrington, 2009). While insurance companies are typically seen as more stable than banks due to their lower liquidity risk (Collet & Ielpo, 2018; Elsinger et al., 2006; Irresberger et al., 2017; Moratis & Sakellaris, 2021), evidence suggests that insurers with multiple lines of business (LOB) and life insurers carry similar systemic risk as high-risk banks (Kaserer & Klein, 2019). According to these analyses, the likelihood of insurers being forced to pay business interruption claims grew with the escalating pandemic impact (Puławska, 2021).

In the United States, the number of lawsuits concerning business interruption coverage surged from March 2020 onwards, as many insurers denied claims related to the pandemic (deLatour, 2021). These insurers argued that the damages were uninsurable, citing the unpredictable nature of the pandemic and its status as a "natural" event, which typically does not cause physical property damage (C. C. French, 2020). Additionally, the widespread economic impact on businesses and households led to an increased demand for compensation, placing further strain on insurers. As a result, insurers faced significant challenges in managing the volume of claims (Ramnath, 2020).

To understand the dynamics of the business interruption insurance market before, during, and after the COVID-19 pandemic, it is relevant to investigate the process of probability updating. This process refers to the change in behavior of economic agents after encountering an event with harmful consequences. Even when such an event does not directly damage policyholders, it can shift their perception of future risks (Fier et al., 2015; Rensi & Carvalho, 2021). As a result, this shift leads to increased demand for protection, as policyholders reassess and adjust their expectations of potential future losses.

3. METHODOLOGY

As an empirical strategy, a two-stage regression model for panel data will be used to capture both the underwriting decision (whether or not to issue policies) and the premium revenue (income) arising from the offering of business interruption insurance coverage.

The first stage of the model estimates the conjunctural effect of the context represented by the pandemic and the characteristics of insurance companies regarding the issuance or non-issuance of business interruption policies, as described by Equation (1).

$$IssueBI_{i,t} = \beta_0 + \beta_1 Size_{i,t} + \beta_2 Leverage_{i,t} + \beta_3 GeoDiver_{i,t} + \beta_4 PortDiver_{i,t} + \beta_5 Group_{i,t} + \beta_6 BrasilGDP_t + \beta_7 ECR_{i,t} + \beta_8 Pand_t \quad (1)$$

where:

$$IssueBI_{i,t} = \begin{cases} 1, if\ PremiumsBI_{i,t} > 0; \\ 0, if\ PremiumsBI_{i,t} = 0. \end{cases} \quad (2)$$

$IssueBI_{i,t}$ is a binary variable that identifies whether insurer i issued a business interruption (BI) insurance policy at time t.

$Size_{i,t}$ indicates the total assets under management of insurer i at time t, in natural logarithmic scale.

$Leverage_{i,t}$ represents the investment conversion rate, defined as the ratio of the net reinsurance premium issued by insurer i at time t to its equity during the same period. A higher rate indicates greater operational efficiency, as the insurer retains more premiums relative to its own capital. The calculation for this rate is provided in Equation (3).

$$Leverage_{i,t} = \frac{Total\ Retained\ Premium_{i,t}}{Total\ Assets_{i,t} - Total\ Liabilities_{i,t}}. \quad (3)$$

$GeoDiver_{i,t}$ represents the geographic concentration level of insurer i's operations at time t, with values ranging from 0 to 1. A value closer to 1 indicates that the insurer operates in more states, while a value closer to 0 reflects more geographically restricted operations. This index is calculated using Equation (4).

$$GeoDiver_{i,t} = 1 - \sum_{s=1}^{S} \left(\frac{Premiums\ Issued_{i,t,s}}{Premiums\ Issued_{i,t}} \right)^2 \quad (4)$$

where i is the insurer, t is the time period and S is the state in which the premium was issued.

$PortDiver_{i,t}$ is an indicator of the portfolio diversification of insurer i at time t, with values ranging from 0 to 1. A value closer to 1 indicates a more diversified portfolio, reflecting activity across a broader range of insurance lines. Conversely, a value near 0 signifies greater specialization, with a focus on a limited number of insurance segments. This parameter is calculated using Equation (5).

$$PortDiver_{i,t} = 1 - \sum_{r=1}^{R} \left(\frac{Premiums\ Issued_{i,t,r}}{Premiums\ Issued_{i,t}} \right)^2 \quad (5)$$

where i represents the insurer, t represents the time and r is the insurance LOB.

$Group_{i,t}$: dummy variable indicating whether insurer i belongs to an economic group at time t (i.e., determined by whether the record in the cogroup field of the SES database differs from 99999), as given by Equation (6)

$$Group_{i,t} = \begin{cases} 1, \text{ if insurer } i \text{ belongs to an economic group in month } t; \\ 0, \text{if insurer } i \text{ doesn't belong to an economic group in month } t. \end{cases} \quad (6)$$

$BrasilGDP_t$: represents the value of Brazil's Gross Domestic Product (GDP) at time t, in natural logarithmic scale.

$ECR_{i,t}$: is the Expanded Combined Ratio (ECR, a classical measure of operational efficiency) of the i-th insurer during the t-th month, as described by Equation (7).

$$ECR_{i,t} = -\left(\frac{Claims + Administrative\ Expenses + Aqcuisition\ Costs}{Premiums\ Earned + Financial\ Income} \right) \quad (7)$$

$Pand_t$: dummy variable that identifies the pandemic months at each point in time, as defined by Equation (8).

$$Pand_t = \begin{cases} 1, during\ the\ pandemic\ months; \\ 0, otherwise. \end{cases} \quad (8)$$

The second stage of the model, outlined in Equation (9), aims to capture the contextual effects of the pandemic, controlled by the insurers' characteristics, on the total direct premiums for business interruption insurance coverages.

$$PremiumsBI_{i,t} = \beta_0 + \beta_1 PremiumsBI_{i,t-1} + \beta_2 Size_{i,t} + \beta_3 Leverage_{i,t} + \beta_4 GeoDiver_{i,t} + \beta_5 PortDiver_{i,t} + \beta_6 Group_{i,t} + \beta_7 BrasilGDP_t + \beta_8 ECR_{i,t} + \beta_9 Pand_t \quad (9)$$

where the explanatory variables are the same as in the first stage. The new dependent variable, $PremiumsBI_{i,t}$, represents the volume of direct premiums issued by insurer *i* for business interruption coverage during the *t*-th period, measured in the natural logarithmic scale. The variable $PremiumsBI_{i,t-1}$ captures the influence of premiums issued in the previous time period.

By adopting this approach, it becomes possible to measure the effects of the pandemic not only on the propensity to underwrite business interruption insurance (first stage) but also on the total value of direct premiums for such policies, while accounting for the idiosyncratic characteristics of the insurers. In other words, the model evaluates both the underwriting decisions (policy issuance) and the financial performance (premium revenue) of insurers in this LOB over time.

Additionally, a control model will be estimated to determine whether the effects of the pandemic on premium volume were consistent across other lines of insurance.

The explanatory variables of this model are the same as those in the two-stage model for the business interruption insurance LOB. The difference lies in the dependent variable: the total amount of premiums issued across all LOBs by the *i*-th insurer at time *t*. This model, therefore, estimates the contextual effect of the pandemic and the characteristics of insurers on the total direct premiums for all coverages offered, as outlined in Equation (10).

$$TotalPremiums_{i,t} = \beta_0 + \beta_1 TotalPremiums_{i,t-1} + \beta_2 Size_{i,t} + \beta_3 Leverage_{i,t} + \beta_4 GeoDiver_{i,t} + \beta_5 PortDiver_{i,t} + \beta_6 Group_{i,t} + \beta_7 BrasilGDP_t + \beta_8 ECR_{i,t} + \beta_9 Pand_t, \quad (10)$$

where $TotalPremiums_{i,t}$ represents the total direct premiums issued by the *i*-th insurer across all LOBs at the *t*-th period, expressed in natural logarithmic terms. The Variable $TotalPremiums_{i,t-1}$ captures the influence of premiums issued in the preceding period.

In addition to examining the search for protection by economic agents, it is important to understand the impact of the pandemic on the expenses incurred by insurers. Therefore, the study also aims to fit a regression model for business interruption claims payments, with the goal of capturing the effects on firms exposed to agreed-upon risks, as outlined in Equation (11).

$$ClaimsBI_{i,t} = \beta_0 + \beta_1 ClaimsBI_{i,t-1} + \beta_2 Size_{i,t} + \beta_3 Leverage_{i,t} + \beta_4 GeoDiver_{i,t} + \beta_5 PortDiver_{i,t} + \beta_6 Group_{i,t} + \beta_7 BrasilGDP_t + \beta_8 ECR_{i,t} + \beta_9 Pand_t \quad (11)$$

where $ClaimsBI_{i,t}$ measures the total volume of claims paid by insurer *i* in the business interruption insurance LOB at time *t*, in natural logarithmic terms. The variable $ClaimsBI_{i,t-1}$ accounts for the influence of claims paid in the previous period.

Similarly to the procedure applied in the second stage, a control model will be estimated to assess the effects of the pandemic on the volume of claims across all insurance LOBs.

$$TotalClaims_{i,t} = \beta_0 + \beta_1 TotalClaims_{i,t-1} + \beta_2 Size_{i,t} + \beta_3 Leverage_{i,t} + \beta_4 GeoDiver_{i,t} + \beta_5 PortDiver_{i,t} + \beta_6 Group_{i,t} + \beta_7 BrasilGDP_t + \beta_8 ECR_{i,t} + \beta_9 Pand_t \quad (12)$$

where $TotalClaims_{i,t}$ represents the volume of claims paid by the *i*-th insurer at time across all its LOBs, expressed in the natural logarithm terms. The variable $TotalClaims_{i,t}$ accounts for the influence of claims paid in the previous period.

4. RESULTS

4.1. Data and Descriptive Statistics

To enable the estimation process, publicly available official datasets from the Brazilian insurance market were used. These datasets are provided by the SUSEP Statistical System (SES), which is fed by the Periodic Information Form (FIP) completed and submitted by entities under SUSEP's supervision, including insurers, reinsurers, open private pension entities, and capitalization societies. These databases provide monthly data on movements of premiums and claims for each reference month, being updated through reloads after analyses by the regulatory body's departments. These data, which cover the period from Jan/2003 to Dec/2023, are organized in a longitudinal structure on a monthly basis for active insurers in order to form an unbalanced panel (i.e., not all firms are observed in all periods). The monetary values are presented in constant Dec/2023 currency and deflated by the Extended National Consumer Price Index (IPCA). The database comprises 25,333 observations from 180 companies over 251 months.

In figure 1(a), as expected, one can observe that the premium data collected from the business interruption insurance sector was relatively insignificant compared to the insurance market in 2023, accounting for only 0.18%. Figure 1(b) shows that the observed increase in the business interruption segment in 2020 (over 120%), combined with a slight recession in the overall insurance market and GDP, may be related to the onset of the COVID-19 pandemic and to the shift in the economic agents' perception of the risk of business interruption.

Next, descriptive statistics for the six variables of interest is presented. Among them, four will be used as explanatory variables in the regression model to be estimated, whereas the remaining two (premiums and claims) will be analysed separately. Table 1 shows to the period from Jan/2003 to Dec/2023. Table 2 provides information for the pre-pandemic period, that is, from Jan/2003 to Feb/2020, when the first Brazilian case was reported. Table 3 presents the same information during the pandemic, spanning from Feb/2020 to Aug/2021, when the administration of the second dose of the COVID-19 vaccine began. Table 4 depicts the post-pandemic period, from Aug/2021 to Dec/2023.

With regard to the variables *premiums* and *claims*, tables 2 and 3 show a 6% increase in premium volume along with an almost 1.5% increase in claim payments for companies offering business interruption insurance. After the pandemic, these companies experienced a more similar increase in premium collection and claim payments, approximately 1.1%.

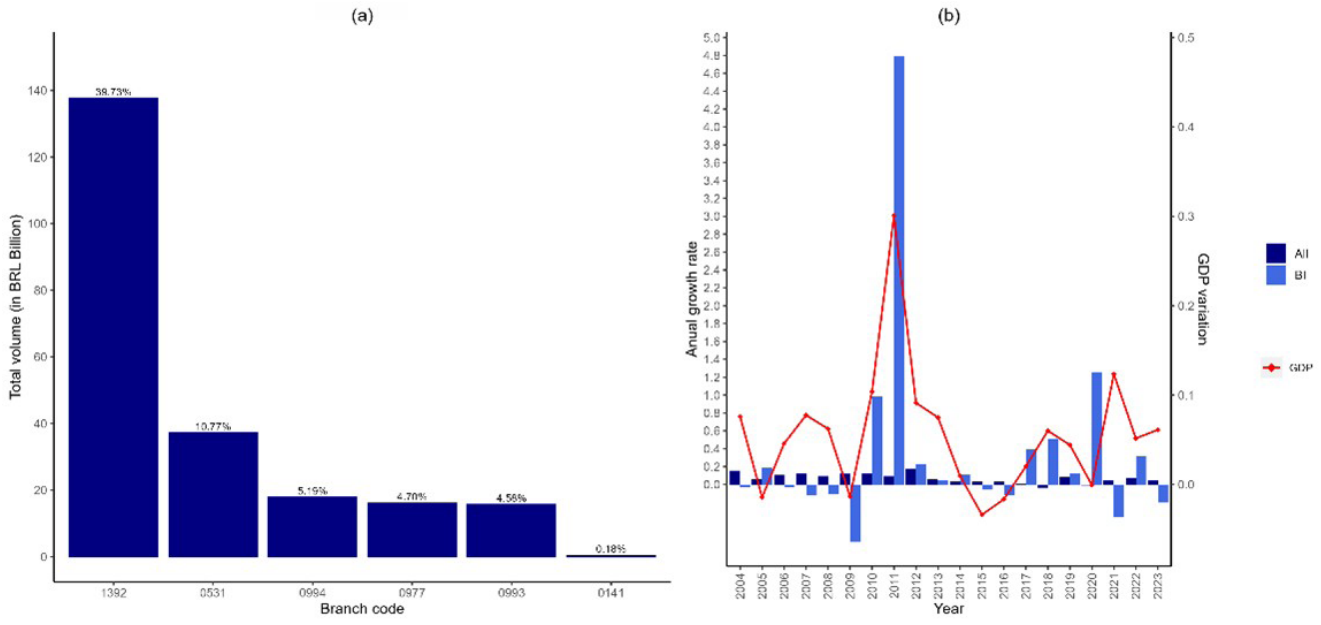

Figure 1 *Direct premiums issued in 2023 (a) and real annual growth of premiums in the insurance market, business interruption premiums, and GDP (b) (2003-2023)*

Source: *Prepared by the authors.*

Table 1
Descriptive statistics from Jan/2003 to Dec/2023

Variables	*size*	*leverage*	*portdiver*	*geodiver*	*group*	*BrasilGDP*	*ECR*	*premiums* (R$)	*claims* (R$)
Mean: all insurers (n=180)	21.55	0.59	0.68	-7.97	0.87	27.30	0.90	15,642,497.81	3,820,305.94
Standard deviation: all insurers	1.73	1.75	0.20	2,334.76	0.33	0.21	39.00	133,175,584.8	18,848,777.30
Mean: insurers that underwrote BI (n=63)	21.73	0.62	0.74	0.54	0.88	27.29	0.73	8,781,411.24	4,248,652.42
Standard deviation: insurers that underwrote BI	1.42	0.57	0.15	14.11	0.33	0.21	2.58	32,029,928.96	20,878,861.66
Mean: insurers that did not underwrite BI (n=117)	21.07	0.49	0.52	-30.66	0.86	27.32	1.33	33,936,777.28	2,678,170.51
Standard deviation: insurers that did not underwrite BI	2.29	3.23	0.24	4,470.44	0.35	0.21	74.54	248,658,092.4	11,766,069.21

Source: *Prepared by the authors.*

Table 2
Descriptive statistics from Jan/2003 to Feb/2020

Variables	*size*	*leverage*	*portdiver*	*geodiver*	*group*	*BrasilGDP*	*ECR*	*premiums* (R$)	*claims* (R$)
Mean: all insurers (n=159)	21.48	0.67	0.68	-10.40	0.90	27.24	0.87	14,804,702.46	3,783,928.08
Standard deviation: all insurers	1.68	1.98	0.20	2,648.00	0.29	0.20	43.88	126,254,716	18,628,858.33
Mean: insurers that underwrote BI (n=57)	21.67	0.71	0.73	0.52	0.90	27.23	0.65	8,392,736.17	4,150,295.04
Standard deviation: insurers that underwrote BI	1.43	0.60	0.15	15.84	0.30	0.21	1.16	30,522,934.13	20,465,580.89
Mean: insurers that did not underwrite BI (n=102)	20.94	0.57	0.52	-40.32	0.91	27.25	1.46	32,368,213.33	2,780,384.10
Standard deviation: insurers that did not underwrite BI	2.15	3.69	0.24	5,120.27	0.28	0.20	84.81	237,972,769.4	12,205,520.08

Source: *Prepared by the authors.*

According to table 1, companies operating in the business interruption insurance sector are generally larger and more capable of converting equity into premiums. Additionally, as shown in tables 3 and 4, these companies tend to diversify their lines of business and geographic reach within the country. On the other hand, their ECR tends to be lower compared to companies that do not offer business interruption insurance. Furthermore, premium collection for companies in this sector is smaller, while claims payments are nearly double those of other companies. These results are similar to those observed in other insurance sectors in Brazil, including (re)insurance (Carvalho & Bonetti, 2023; Carvalho & Song, 2024). According to Rensi & Carvalho (2021), this behavior was also observed in the executive liability insurance sector during the context of the Operation Car Wash, described as the largest anti-corruption initiative in the world.

In tables 1 and 2, the negative values of the variable *geodiver* are explained by the presence of negative premiums in certain months for some companies. These negative premiums represent reversals of amounts (i.e., refunds to the insured) or errors in data entry when completing Susep's Periodic Information Form.

Table 3
Descriptive statistics from Feb/2020 to Aug/2021

Variables	*size*	*leverage*	*portdiver*	*geodiver*	*group*	*BrasilGDP*	*ECR*	*premiums* (R$)	*claims* (R$)
Mean: all insurers (n=113)	21.83	0.27	0.70	0.45	0.78	27.44	1.08	18,024,587.73	3,791,289.67
Standard deviation: all insurers	1.81	0.28	0.20	6.02	0.41	0.06	16.63	156,239,635.5	17,173,799.13
Mean: insurers that underwrote BI (n=39)	22.07	0.29	0.78	0.63	0.78	27.44	0.95	8,874,244.82	4,208,388.29
Standard deviation: insurers that underwrote BI	1.24	0.26	0.13	0.75	0.41	0.06	0.13	30,767,689.66	19,263,379.87
Mean: insurers that did not underwrite BI (n=74)	21.42	0.25	0.57	0.13	0.79	27.44	1.30	33,390,588.95	3,090,863.71
Standard deviation: insurers that did not underwrite BI	2.44	0.32	0.23	9.80	0.41	0.06	27.23	251,875,148.8	12,896,637.24

Source: *Prepared by the authors.*

Table 4
Descriptive statistics from Aug/2021 to Dec/2023

Variables	*size*	*leverage*	*portdiver*	*geodiver*	*group*	*BrasilGDP*	*ECR*	*premiums* (R$)	*claims* (R$)
Mean: all insurers (n=124)	21.82	0.29	0.71	0.60	0.75	27.53	0.96	18,917,553.29	4,047,526.82
Standard deviation: all insurers	1.88	0.28	0.20	3.88	0.43	0.04	0.72	154,043,834.9	21,005,329.48
Mean: insurers that underwrote BI (n=39)	22.13	0.28	0.79	0.63	0.77	27.53	0.95	10,031,563.7	4,834,932.55
Standard deviation: insurers that underwrote BI	1.23	0.21	0.12	4.86	0.42	0.04	0.24	37,981,831.72	23,319,743.05
Mean: insurers that did not underwrite BI (n=85)	21.35	0.30	0.58	0.55	0.71	27.53	0.96	32,179,337.21	2,872,372.99
Standard deviation: insurers that did not underwrite BI	2.48	0.36	0.24	1.38	0.45	0.04	1.09	238,116,858	16,906,713.24

Source: *Prepared by the authors.*

As shown in figures 2(a) and 3, claims payments and premiums generally followed their natural progression in the insurance market, whether or not the Business Interruption Insurance sector (LOB 0141) was included.

For comparison, the behaviors of Automobile-Casco insurance (LOB 0531) and Pension insurance (LOBs 1392 and 1394) were analyzed. In figure 4(a), a significant decline in indemnity payments during the first months of 2020 is highlighted, coinciding with the imposition of restrictive measures to combat the spread of the virus, which led to a reduction in car traffic volume. As a result, fewer accidents and other vehicle-related incidents occurred.

In turn, figure 4(b) shows that, despite increased variability, the premium revenue of companies operating in complementary pensions followed the same linear growth trend, while claims coverage remained low compared to premium issuance. This is due because this LOB operates with a financial accumulation product under a fully funded regime, resulting in a significant time mismatch between the financial accumulation period and the provision of benefits.

However, when analyzing figure 2(b), it can be observed that claims payments in the Business Interruption Insurance LOB experienced significant variations starting in 2018, with a peak around early 2022. In contrast, the premium revenue of insurers remained stable and, proportionally, much lower than the expenses arising from claims.

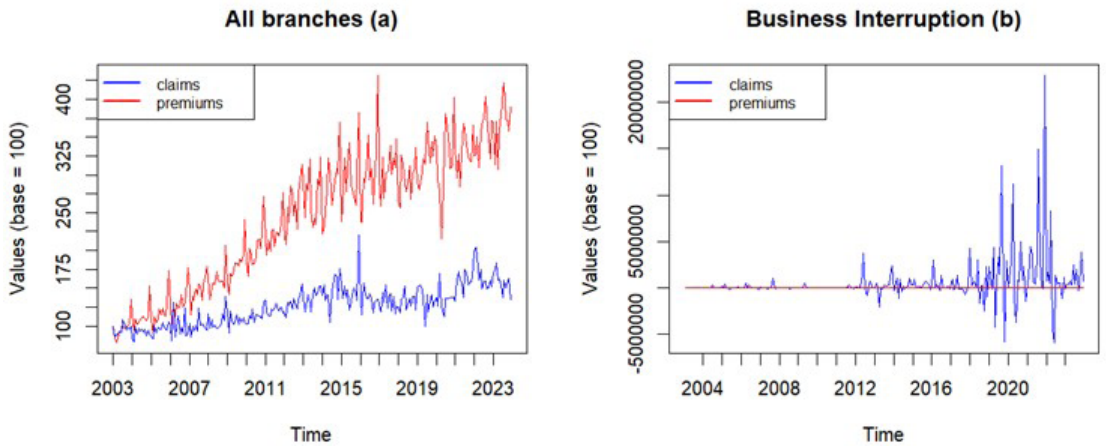

Figure 2 *Evolution of premium revenue and claim payments (base=100) across the entire insurance market (a) and in the Business Interruption LOB (b), from Jan/2003 to Nov/2023*

Source: *Prepared by the authors.*

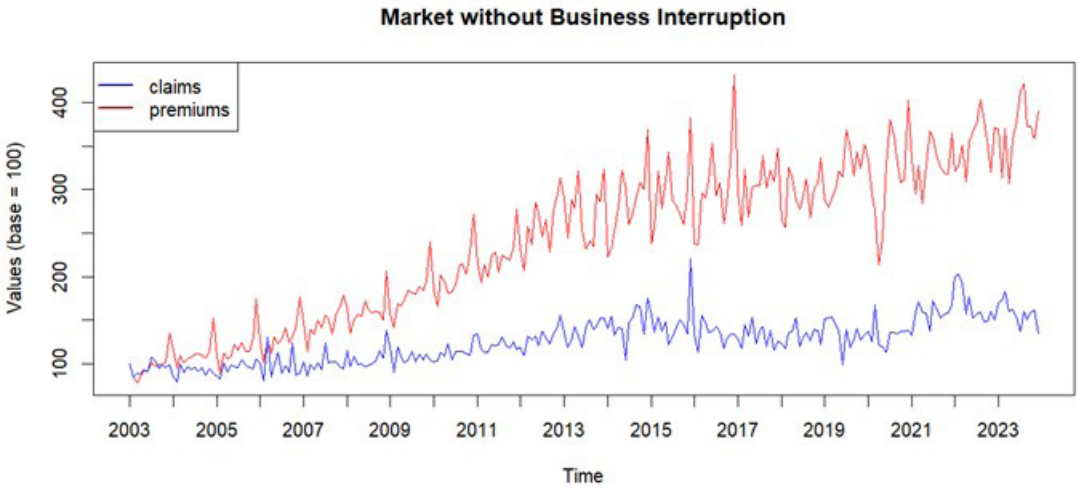

Figure 3 *Evolution of premium revenue and claim payments (base=100) across the entire insurance market, excluding the Business Interruption LOB, from Jan/2003 to Nov/2023*

Source: *Prepared by the authors.*

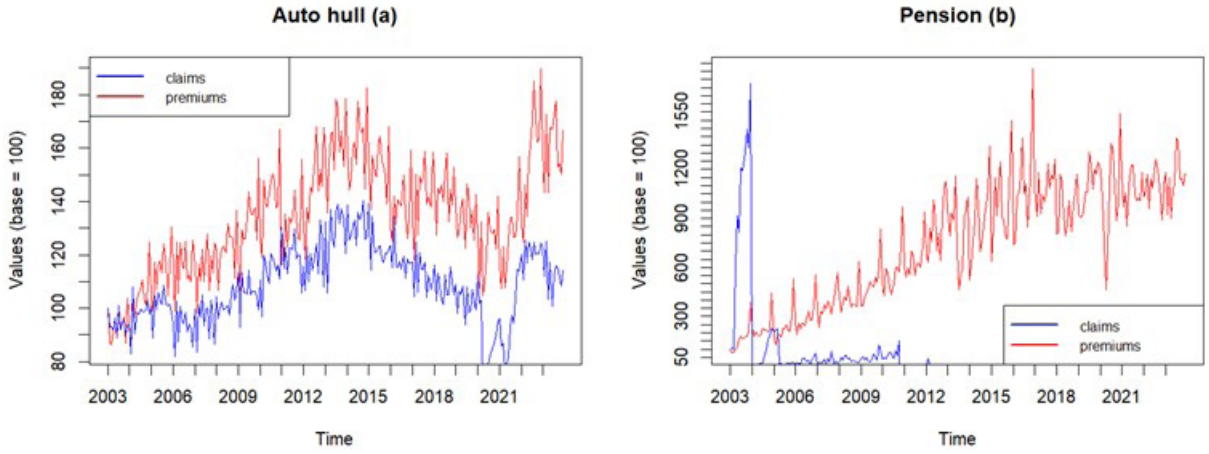

Figure 4 *Evolution of premium revenue and claim payments (base=100) in the Auto Hull and Pension LOBs, from Jan/2003 to Nov/2023*

Source: *Prepared by the authors.*

4.2 The Regression Models

This study aims to assess whether the advent of the pandemic has a significant impact on the decision to offer business interruption insurance, as well as on the volume of premiums received and claims paid, using regression models. As a control, the effect of the pandemic on the volume of premiums and claims paid across all insurance LOBs is measured to determine whether the influence of this event is specific to the business interruption insurance LOB. Additionally, the study seeks to evaluate the probability updating effects in the business interruption insurance market caused by the pandemic, through the segmentation of relevant periods of evolution.

To assess the probability of underwriting business interruption insurance by insurers, a probit regression model for panel data is estimated (first stage of the model). In the second stage, conditional on the first, linear models for unbalanced panel data are estimated to determine the extent of coverage. This linear model is also applied to the entire insurance market to evaluate whether the effects of the pandemic are specific to the business interruption insurance sector. The results are presented in table 5.

The results from the estimation of the panel probit model for the underwriting choice in the BI sector, via Equation (1), reveal that larger, more efficient companies, and those that diversify their lines and states of operation more intensively, are more likely to offer business interruption insurance. Furthermore, *caeteris paribus*, for every 1% increase in national GDP, the probability of underwriting business interruption insurance increases on average by 1.676%.

On the other hand, companies that belong to a corporate group have a lower probability of entering the business interruption insurance market. The *Pand* variable, in addition to being significant, has a positive coefficient. Therefore, it can be concluded that, as the pandemic scenario evolved, insurers were more likely to operate in this sector.

In the second stage of the model, which focuses exclusively on the premium revenue in the business interruption insurance sector, the same pattern found in the previous stage is observed regarding company size, the ability to convert equity into premiums (*Leverage*), portfolio diversification, and the increase in GDP. In this case, belonging to a corporate group also positively influences premium volume. Geographic diversification and the pandemic, which are not significant for the model, show positive coefficients. Notably, in this model, the variable *ECR* is significant. The higher the *ECR* (i.e., indicating less operationally efficient companies), the higher their premium revenue. Additionally, the volume of premiums collected by the insurer in the previous month (*Lag*) is strongly positively relevant.

For the final model, defined by Equation (9), which provides information on all sectors of the insurance market, the four significant characteristics from the previous models exhibit the same behavior. Additionally, the variable *Group* shows strong negative significance. In this model, the variable *Lag(Premiums)* is also positively significant.

The hypothesis regarding the effect of the Coronavirus pandemic on demand's probability updating for business interruption insurance market is based on changes in the perception of the risk of future losses due to the potential economic consequences arising from the evolution of the event of interest (Fier et al., 2015; Rensi & Carvalho, 2021). Therefore, it is more appropriate to segment the pandemic into different periods based on its evolution and developments. For this purpose, the time milestones defined in table 6 are selected.

The results of models (1), (9), and (10), considering these divisions, are presented in table 7.

The results of model (1) clearly indicate a decrease in the probability of more insurers offering business interruption insurance as the pandemic persisted, signaling a contraction in the availability of this coverage. This may have occurred due to legal uncertainty and/or worsened expectation of future claims.

The effects found for model (9) further reinforce the hypothesis of probability updating. First, this is reflected in the consistent reduction in the effect size, and then in the transition from insignificant to significant in third period. Initially, there was a maintenance of business interruption insurance premiums, which decreased over time, either due to a reduction in premium prices or a decline in the underwriting of policies involving business interruption coverage.

For the control model in the second stage, the third phase of the pandemic is significant. Unlike the behavior in the business interruption insurance sector, the volume of premiums collected by insurance companies increased in line with the progression of the pandemic. Thus, it is evident that the business interruption insurance sector shows a trend opposite to that of the overall insurance market, reinforcing the possibility that the pandemic specifically affected business interruption insurance. The only parallel in the literature, is the case of Operation Car Wash involving executive insurance, as documented by Rensi & Carvalho (2021), which found empirical evidence of probability updating in the insurance market.

Table 5
Results of the model estimations for the equations (1), (9) and (10)

Variables	(1)Decision to offer BI		(9)Premium volume: BI (LOB 0141)		(10)Premium volume: all LOBs	
	Coefficient	Standard-error	Coefficient	Standard-error	Coefficient	Standard-error
Intercept	-53.650***	2.1340	–	–	–	–
Lag(TotalPremiums)	–	–	0.4856***	0.0133	0.6994***	0.0048
Size	0.2427***	0.0110	0.3672***	0.0609	0.2942***	0.0086
Leverage	0.0193*	0.0076	0.6113***	0.0730	0.0103***	0.0015
GeoDiver	0.1512***	0.0417	0.0184	0.0731	0.0000*	0.0000
PortDiver	3.5040***	0.0954	3.3726***	0.2964	0.1353***	0.0300
Group	-0.0753.	0.0417	0.3046*	0.1407	-0.1190***	0.0251
BrasilGDP	1.676***	0.0781	0.8864***	0.2124	-0.2587***	0.0288
ECR	0.0000	0.0006	0.3696***	0.0948	-0.0001	0.0001
Pand	0.3355***	0.0541	0.0176	0.0594	-0.0029	0.0148
Firms			58		178	
Observations			4,351		23,148	
Period			1-201		1-231	
R-Squared			0.3553		0.7118	
Adjusted R-Squared			0.3454		0.7095	
Hausman Test p-value			<0.001		<0.001	
Estimation type			Fixed effects		Fixed effects	

Note: ****/**/*/. indicate significance at the levels of 0.1%, 1%, 5% e 10%, respectively.*
Source: *Prepared by the authors.*

Table 6
Relevant timeframes of different phases of the Pandemic

Period	Period	Period Characteristics
1	Feb/2020–Jan/2021	From the first documented case to the application of the first dose of the COVID-19 vaccine in Brazil.
2	Feb/2021–Aug/2021	Flexibilization of circulation restrictions.
3	Sep/2021–Dec/2023	Start of the administration of the second dose of the COVID-19 vaccine.

Source: *Prepared by the authors.*

However, Rensi and Carvalho (2021) did not assess the effects on the volume of claims resulting from the exogenous shock. Therefore, the present study goes beyond estimating the effects of the pandemic on revenues by addressing the following question: was the pandemic capable of generating more expenses in the business interruption insurance sector than in other sectors of the insurance market? To answer this question, the same pandemic segmentation into three periods (Table 6) was applied in the analysis of claims payments. The results are presented in tables 8 and 9.

In table 8, it is observed that larger companies pay more claims, and the volume of claims paid in the previous month is positively significant. Additionally, for model (11), companies belonging to an economic group also have a positive influence on the volume of claims paid, as does portfolio diversification. In contrast, the national GDP shows significant negative impacts only in model (12), with the variable *ECR* being negatively significant, meaning that the lower the *ECR* value, the higher the volume of claims paid. On the other hand, the variable *Pand* is significant and positive in both models. Therefore, it can be inferred that the volume of claims paid by insurers, both for business interruption insurance and for the insurance market as a whole, increased as the pandemic progressed.

Table 7
Results of the model estimations for the equations (1), (9) and (10) with a breakdown of relevant periods of the Pandemic

Variables	(1)Decision to offer BI		(9)Premium volume: BI (LOB 0141)		(10)Premium volume: all LOBs	
	Coefficient	Standard-error	Coefficient	Standard-error	Coefficient	Standard-error
Intercept	-45.940***	2.3230	–	–	–	–
Lag(TotalPremiums)	–	–	0.4853***	0.0133	0.6975***	0.0048
Size	0.2717***	0.0110	0.3511***	0.0613	0.2959***	0.0086
Leverage	0.0215**	0.0080	0.6155***	0.0731	0.0104***	0.0015
GeoDiver	0.1462***	0.0424	0.0229	0.0731	0.0000*	0.0000
PortDiver	3.3810***	0.0948	3.4308***	0.2978	0.1254***	0.0301
Group	-0.1275**	0.0427	0.3200*	0.1409	-0.1229***	0.0251
BrasilGDP	1.3720***	0.0851	1.1722***	0.2460	-0.3065***	0.0306
ECR	0.0000	0.0006	0.3011**	0.0997	-0.0001	0.0001
Pand1	0.4839***	0.0680	0.0357	0.0757	0.0092	0.0187
Pand2	0.3545***	0.0867	-0.1307	0.0949	0.0299	0.0232
Pand3	0.3735***	0.0534	-0.1294*	0.0643	0.0667***	0.0145
Firms			58		178	
Observations			4,351		23,148	
Period			1-201		1-231	
R-Squared			0.3562		0.7121	
Adjusted R-Squared			0.3459		0.7097	
Hausman Test p-value			<0.001		<0.001	
Estimation type			Fixed effects		Fixed effects	

Note: ****/**/*/. indicate significance at the levels of 0.1%, 1%, 5% e 10%, respectively.*
Source: *Prepared by the authors.*

Table 8
Results of the model estimations for the equations (11) and (12), without a breakdown of different periods of the Pandemic

Variable	(11)Claim volume: BI (LOB 0141)		(12)Claim volume: all LOBs	
	Coefficient	Standard-error	Coefficient	Standard-error
Intercept	–	–	–	–
Lag(TotalPremiums)	0.3138***	0.0250	0.5321***	0.0058
Size	0.8876***	0.1999	0.3577***	0.0126
Leverage	0.3120	0.2554	0.0027	0.0020
GeoDiver	-0.3358*	0.1422	0.0000	0.0000
PortDiver	1.7740.	0.9622	0.7240***	0.0475
Group	0.9796*	0.4430	-0.0676.	0.0357
BrasilGDP	0.8786	0.7643	-0.3952***	0.0435
ECR	0.1173	0.2791	-0.0025**	0.0009
Pand	0.4293**	0.1631	0.0436*	0.0220
Firms	45		171	
Observations	1390		19156	
Period	1-86		1-231	
R-Squared	0.1646		0.4949	
Adjusted R-Squared	0.1314		0.4902	
Hausman Test p-value	<0.001		<0.001	
Estimation type	Fixed effects		Fixed effects	

Note: ****/**/*/. indicate significance at the levels of 0.1%, 1%, 5% e 10%, respectively.*
Source: *Prepared by the authors.*

Table 9
Results of the model estimations for the equations (11) and (12), with a breakdown of different relevant periods of the Pandemic

Variable	(11)Claim volume: BI (LOB 0141)		(12)Claim volume: all LOBs	
	Coefficient	Standard-error	Coeficiente	Standard-error
Intercept	–	–	–	–
Lag(TotalPremiums)	0.3135***	0.0250	0.5270***	0.0058
Size	0.8693***	0.2024	0.3648***	0.0126
Leverage	0.3266	0.2563	0.0027	0.0020
GeoDiver	-0.3387*	0.1422	0.0000	0.0000
PortDiver	1.7436.	0.9691	0.7083***	0.0475
Group	0.9696*	0.4450	-0.0787*	0.0357
BrasilGDP	0.9758	1.0584	-0.5134***	0.0464
ECR	0.1107	0.2878	0.0025**	0.0009
Pand1	0.5991**	0.2050	0.0122	0.0277
Pand2	0.1850	0.2784	0.2030***	0.0347
Pand3	0.0442	0.2083	0.1356***	0.0214
Firms	45		171	
Observations	1,390		19,156	
Period	1-86		1-231	
R-Squared	0.1658		0.4965	
Adjusted R-Squared	0.1315		0.4917	
Hausman Test p-value	<0.001		<0.001	
Estimation type	Fixed effects		Fixed effects	

Note: ****/**/*/. indicate significance at the levels of 0.1%, 1%, 5% e 10%, respectively.*
Source: *Prepared by the authors.*

In table 9, the observations regarding all variables (except for *ECR*, which is positively significant for the overall insurance market, and the *dummy Pand*) are interpreted as previously described. However, the divisions of the pandemic period reveal that the pandemic led to opposite behaviors in the response variable of each model. Particularly in the business interruption insurance sector, the first period was significant and positive, indicating an immediate increase of 0.60% in the volume of claims paid by companies offering BI insurance. However, the following periods tended to return to pre-pandemic levels, a phenomenon that can be explained by the reduced offering of business interruption insurance and possible legal disputes between insured parties and insurers regarding the legality of coverage. For the overall insurance market, periods 2 and 3 are significant and positively related to the volume of claims paid. Thus, it is evident that the progression of the pandemic increased the volume of claims paid by insurers.

Based on the information obtained from the regression models, it can be concluded that the COVID-19 pandemic had a distinct impact on the business interruption insurance market. The pandemic led companies to reduce the offering of policies with this coverage, decreased premium collection, and mitigated the growth of claims paid within this sector. This behavior was observed through the segmentation of the event into crucial periods, supporting the hypothesis of probability updating. Furthermore, the results for the overall insurance market were completely opposite to those for business interruption, highlighting the uniqueness of the pandemic's effect on this sector.

5. PRACTICAL AND MANAGERIAL IMPLICATIONS

This study provides robust evidence on the behavior of the insurance market, specifically in the business interruption sector, during an adverse situation like the pandemic, an exogenous shock of significant magnitude. Such shocks, in addition to potentially impacting insurers in different sectors in distinct ways, also alter the risk

perception of economic agents as they evolve. In this context, the phenomenon of probability updating explains these practical reactions, and the estimated models serve as essential tools for measuring the practical and financial effects of such occurrences.

Thus, risk managers in insurance companies can benefit from the results presented here. The reactions of the insurance market in complex environments (e.g., pandemics) highlight the need for robust mechanisms to protect insurers' solvency. The primary way to address these adverse contingencies is by developing a rigorous process for evaluating the risks incurred by policyholders. High-magnitude events drastically alter risk perception for both policyholders and companies, requiring swift adjustments in actuarial models and premium pricing.

Finally, industry regulators and lawmakers can leverage the findings of this research to better understand the impact of legislation and public policy on the insurance sector. The legal disputes triggered by the pandemic underscore the urgent need to revisit and clarify the terms of business interruption insurance policies, specifically in terms of coverage and exclusions. Moreover, the pandemic highlights the importance of reviewing the contractual conditions of policies across other insurance sectors, particularly those vulnerable to exogenous shocks, including risks stemming from contractual gaps or ambiguities (e.g., liabilities).

6. FINAL CONSIDERATIONS

Business interruption insurance provides coverage to policyholders for income loss during a specified period, triggered by a covered event outlined in the policy, and typically requires the activation of a primary insurance policy. With the onset of the COVID-19 pandemic, this type of insurance has become a focal point of studies and legal disputes, particularly due to disagreements over the interpretation of contract clauses.

In Brazil, the sector has undergone significant changes, largely driven by the pandemic, its economic aftermath, and the evolving risk perception among economic agents. This shifting perception influences the behavior of policyholders, particularly in terms of claims volume, and may also impact insurers' decisions regarding their involvement in this market segment. This phenomenon, referred to as probability updating, captures the gradual adjustments in underwriting dynamics and the scope of business interruption coverage as a result of the ongoing evolution of the pandemic.

A general analysis of the business interruption insurance market in Brazil was conducted using data from SES-Susep, spanning from 2003 to 2023. Additionally, a two-stage regression model for panel data was employed to estimate the impact of the COVID-19 pandemic on the insurance market, with a particular focus on the business interruption sector. The findings highlight that the pandemic had a profound effect on insurers' behavior within this segment.

The results also reveal that the pandemic led to a shift in risk perception among economic agents, initially driving an increase in premium collections and claims payments within the business interruption insurance sector. However, as the pandemic progressed, insurers became less active in this LOB, significantly reducing premium income. In contrast, the broader insurance market experienced growth in revenues during the same period.

In terms of claims payments within the business interruption insurance market, an initial positive shock was observed, suggesting that insurers were called upon more frequently to settle claims in this LOB. However, in contrast to the overall market, where claims payments showed signs of growth, the volume of claims for business interruption insurance began to decrease, eventually returning to pre-pandemic levels. This decline in claims payments may be attributed to potential legal disputes over whether pandemic-related losses were covered and to the reformulation of contracts containing business interruption clauses.

Thus, it can be inferred that the pandemic altered the perception of both policyholders and insurers regarding the sustainability of capital inflow into certain economic activities. This shift, in turn, led to a search for solutions that could make such arrangements viable, aligning with the concept of probability updating. Following the initial surge in claims payments, insurers became less inclined to offer business interruption insurance. Consequently, it is likely that the volume of premiums, either through a reduction in policies sold or adjustments in pricing, declined as the pandemic progressed, while claims payments stabilized once again.

For future research, it is suggested to explore the impacts of the pandemic on sectors more vulnerable to risk of insolvency. Examples include the supplementary health and life insurance sectors, which were impacted by population health issues, increased demand for

outpatient and hospital care, as well as the postponement of treatments and diagnoses for other diseases. The transportation sector, which plays a critical role in both urban mobility and the export-driven agribusiness, is another segment that warrants attention. Additionally, it is proposed to examine the behavior of the insurance market following the 2024 tragedy in Rio Grande do Sul, assessing its effects on industry dynamics and risk management practices.

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