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Regulatory proportionality in Brazilian pension funds in light of predominant sponsorship

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ABSTRACT

This article evaluates the results of the regulatory proportionality adopted in Brazil for closed supplementary pension entities classified as Systemically Important Entities (SIEs), emphasizing the predominance of sponsorship, whether public or private. The article also determines whether the approach benefited pension funds and the economic environment or proved unnecessary and costly. The researchers sought to assess the influence of governance on asset management, investment performance, and risk management. The study measured whether the effects of the new regulation are similar and positive among entities with predominantly public and private sponsorship. Brazilian pension funds are significant due to their "economic aspect" (they are institutional investors with R$1.3 trillion in assets in 2023, equivalent to 12% of gross domestic product) and their "social aspect" (they are linked to public policies and aspects related to individuals' pursuit of economic security tied to longevity, and they covered 3.9 million participants in 2023). This research contributes to regulators by suggesting that extending regulatory proportionality to other publicly sponsored funds is timely and beneficial. This would strengthen regulatory oversight and provide greater security to participants, sponsors, and financial and capital markets, thus mitigating risks to the economy. The study used continuous time series to analyze the trajectory of variables before and after the adoption of the new regulation. Estimation methods such as Kruskal-Wallis, differences-in-differences, and differences-in-differences-in-differences were applied, as well as principal component analysis. The results indicate that the benefits of regulatory dosimetry outweigh the incremental costs, and the new regulation protects participants, sponsors, and the market. However, it protects publicly sponsored funds to a lesser extent, as these funds have larger asset holdings and a greater number of participants. There is no evidence of regulatory inflation.

Keywords: regulatory cost, pension funds, regulatory impact, supplementary pension plans, sponsorship predominance.

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1. INTRODUCTION

The formation and development of the capitalist system was influenced, among other factors, by the advent of "Calvinist ethics" in the early 16th century. The theological endorsement of economic gain and wealth accumulation served as a favorable stimulus for the evolution of the capitalist market economy (Rossetti & Andrade, 2014, p. 33). This strengthened property rights in an individualistic vein, allowing for greater protection of wealth accumulation and the owner's right to "use, enjoy, and dispose of" their assets.

According to Assis (2008, p. 789), "Property arises as an absolute concept. It is thus enshrined in the earliest constitutions in the history of civilizations, which declare the right to property a natural human right." Among Brazil's fundamental rights is the principle that "the owner has the power to use, enjoy, and dispose of their property, and the right to reclaim it from anyone who unjustly owns or holds it" (Law No. 10,406, January 10, 2002).

The "intergenerational pact," a social security system adopted by many countries based on a pay-as-you-go model where the current generation funds retirees from previous generations, has been challenged by rising life expectancy, which increases the duration of benefit receipt, and the decline in the population's fertility rate. In Brazil, the government advocates for a new social security reform aimed at achieving actuarial balance, citing the existence of a deficit (Lavinas & Araújo, 2017; Lemes & Fonseca, 2023; Rocha & Macário, 2016). Conversely, some argue that there is no deficit and point to methodological inconsistencies in the calculations as well as the failure to allocate the resources provided for in the Constitution (Correia, 2016; Wolf & Buffon, 2025).

Therefore, individuals have begun to view asset accumulation as a reserve to ensure their livelihood after retirement and to supplement public pension benefits, which are not always sufficient or guaranteed to maintain their attained quality of life.

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In this challenging scenario, private pension plans have gained importance as a complement to public pensions. They are valued for their "economic aspect" as a source of long-term investment financing and for their "social aspect," as they are connected to public social policies and aspects related to the individual, such as the pursuit of economic security associated with longevity. Furthermore, pension funds can impact a country's economic health, as the collapse of a large fund represents systemic risk with the potential to generate negative consequences for the economic and social order. This is due to the interdependence of the funds, which face risks that must be managed to mitigate systemic risk, and their interconnectivity with financial and capital markets, which promotes economic development through productive investments and the generation of long-term savings.

Brazil's Constitution of 1988 established a "private pension system" as a supplementary system based on the accumulation of reserves to guarantee contracted benefits. This system operates in "open" and "closed" forms. "Open private pension plans" are operated by banks, entities, or insurance companies that offer them to individuals and legal entities. "Closed private pension plans" are operated by closed supplementary pension entities (CSPEs) or pension funds sponsored by legal entities, public companies, or legal entities of a professional, occupational, or sectoral nature.

In recent years, Brazil has experienced financial scandals in the pension fund sector, particularly in publicly sponsored CSPEs. These scandals have led to investigations such as the 2015 Pension Fund Parliamentary Inquiry Commission (PIC), which was established to investigate mismanagement, political interference, and fraud in funds sponsored by public enterprises. The PIC found losses totaling R$113.4 billion due to asset devaluation (Chamber of Deputies, 2016). Another investigation, Operation Greenfield, was launched in 2016 to probe the embezzlement of funds through investments in private equity funds. This resulted in losses of R$5.1 billion (Saraiva, 2021, pp. 230–231).

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Therefore, there is evidence that CSPEs require robust governance systems grounded in principles that balance the relationship between principals (sponsors and fund participants focused on asset security and investment risk and return) and agents (executive managers focused on business control, operational strategy, and risk management) while preserving participants' rights and savings. To protect the interests of sponsors and participants, regulators have responded by establishing or proposing new rules for pension funds. In Brazil, the National Superintendence of Supplementary Pension Plans (PREVIC) strengthened the regulatory framework in 2018 by instituting additional prudential measures for CSPEs. PREVIC classified these CSPEs as Systemically Important Entities (CSPE-SIEs) due to their size and relevance to the closed supplementary pension system (PREVIC, 2017a, 2017b).

The research question is whether regulatory proportionality increased the assets of CSPE-SIEs, improved their solvency (i.e., their ability to meet long-term obligations), and enhanced the representativeness of pension expenses and the number of participants, or if it constituted a drain on valuable resources that could have been used to maximize value for participants. To this end, the study empirically measured whether PREVIC's regulatory intervention had similar and positive effects on CSPEs with predominantly public and private sponsorship. The following research question was considered: Did regulatory proportionality applied to CSPE-SIEs in Brazil converge to reduce systemic risk, improve solvency, and balance private pension fund autonomy with state intervention, having a greater effect on CSPEs with public sponsorship than on those with private sponsorship?

In this context, the following research hypothesis is proposed:

H_1: Publicly sponsored CSPEs exhibit worse indicators (assets, solvency, administrative expenses, and number of participants) than privately sponsored CSPEs, in both the SIE ("treatment") group and the non-SIE ("control") group.

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This research distinguishes itself from previous studies by measuring whether the effects of regulatory proportionality are similar between publicly and privately sponsored funds, as previous studies have focused on measuring the influence of governance on the management and performance of assets. This research not only fills a gap in the literature but is also justified by the social importance of supplementary pension plans given their link to public policies and potential economic impact.

2. THEORETICAL FRAMEWORK

2.1 Demographics of Pension Funds in Brazil

In 2023, there were 269 CSPEs with assets of R$1.28 trillion (R$0.7 trillion in 2014), which PREVIC classified into two major groups: SIEs (PREVIC, 2017b) and non-SIEs. SIE funds accounted for 64% of total assets and 31% of participants (Table 1).

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Table 1

Distribution of closed supplementary pension entities (CSPEs) classified into the Systemically Important Entities (SIEs) and non-SIEs groups

Group	Classification by total assets (R$)	CSPE		Plans		Population		Total assets Dec/23	
		n	%	n	%	n	%	R$ million	%
Non-SIEs									
Group 4	Up to 100 million	37	14	86	5	52,087	1	1,301	0
Group 3	100 to 500 million	59	22	136	8	200,179	5	16,865	1
Group 2	500 million to 2 billion	83	31	286	17	575,703	15	90,039	7
Group 1	Over 2 billion	73	27	951	56	1,873,000	48	355,982	28
SIEs		17	6	227	13	1,231,036	31	819,365	64
Total		269	100	1,686	100	3,932,005	100	1,283,552	100

Source: *Prepared by the authors based on data from the National Superintendence of Supplementary Pension Plans (PREVIC, 2023).*

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2.2 Aspects of Regulation and Oversight in Pension Funds

Baldwin et al. (2012, pp. 27–38) advocate a five-criteria approach to legitimizing the regulatory process: (i) regulation supported by mandated legislative authority, (ii) adequate accountability and oversight of the regulator, (iii) due process of law, (iv) sufficient expertise of the regulator, and (v) efficient implementation of the legislative mandate.

The risk arises when the state engages in excessive regulation in an effort to better control the market. This regulation is often difficult to comply with and has an unreasonable economic impact, thereby restricting freedom of action and decision-making. Biondi (1953, as cited by Silva, 1968, p. 77) referred to the unbridled production of laws as "legislative elephantiasis." Carnelutti (2003, p. 11) defined legislative inflation, or "hypertrophy of the law," as the mass production of laws that creates chaos in the legal system.

CSPEs must pursue good governance practices to manage their resources in the best possible way and honor the payment of social security benefits (Reis et al., 2019, p. 34).

The International Organization of Pension Supervisors (IOPS, 2006) developed the IOPS Principles of Private Pension Supervision, which provide guidelines on independence, resource and power adequacy, risk orientation, regulatory proportionality, and governance. The Organization for Economic Cooperation and Development (OECD, 2016) defined the Core Principles of Private Pension Regulation to encourage regulation that enhances the credibility of the pension system and maintains participants' confidence. Brazil established PREVIC, replacing the Secretariat of Supplementary Pension Plans, to inspect and supervise CSPEs (Law No. 12,154, December 23, 2009). PREVIC has begun strengthening its regulations, including introducing regulatory proportionality for SIEs in 2018, which requires them to implement additional prudential measures (Table 2).

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Table 2
Regulatory proportionality for SIEs

Rule	Description
Certification and qualification of officers	SIEs must have all members of the board of directors, deliberative council, and fiscal council qualified by PREVIC. Board members designated as a TQSA of a CSPE-SIE must be interviewed to obtain a qualification certificate.
Audit committee	The establishment of an audit committee is mandatory for CSPE-SIEs. At least one committee member must have knowledge of CSPE accounting and auditing.
Risk management committee	SIEs must separate resource management from risk management. The TQSA is responsible for resource management, while a second administrator or committee is responsible for risk management. Both must perform their duties independently and without hierarchical subordination to one another.
Independent auditor	CSPE-SIEs must engage an auditor to issue a specific report on the adequacy of internal controls in relation to the risks borne, as well as the governance of the CSPE.

TQSA = technically qualified statutory administrator; CSPEs = closed supplementary pension entities; SIEs = Systemically Important Entities.
Source: *Prepared by the authors based on data from the National Superintendence of Supplementary Pension Plans (PREVIC, 2017a, 2018a, 2018b).*

From a regulatory impact perspective, Papík and Papiková (2021) analyzed Slovak pension funds. They concluded that legislative interventions impact fund performance, causing the average daily return to decrease by 0.01% to 0.03% with each intervention. Souto and Musalem (2012, p. 156) studied publicly sponsored pension funds in 68 countries, concluding that sound governance structures are essential given the "need for comprehensive transparency in the use of public resources that will be used in the future to fulfill current promises, thereby affecting the taxation of future generations." Cardoso et al. (2025, p. 1) evaluated the impact of regulations establishing more refined governance mechanisms in investment processes on Brazil's CSPEs and concluded that "despite the flexibility of the new regulations, there are no differences in potential returns given the overlap of the efficient frontiers of the models under each regulation." Freitas and Carvalho (2024) and Teixeira et al. (2025) concluded that regulatory improvements are needed to mitigate earnings management risks through the administration of actuarial assumptions for solvency calculations. Azambuja and Campani

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(2022) suggest that PREVIC adopt a consistent actuarial method for pension plans to make solvency levels more reliable.

3. METHODOLOGY

This research employs a continuous time series approach based on Gaglio and Glasgow's (2017) study, which discusses quantitative methods for evaluating implementation research studies. The study focuses on "summative evaluation," which characterizes and quantifies the impact of an implementation strategy on various outcomes over time. It examined the impact of proportional regulation on CSPE-SIEs via cost-effectiveness analyses. The results can help the sector regulator understand the overall value of the regulatory implementation strategy and decide whether to expand, modify, or discontinue it (Bauer et al., 2015).

3.1 Event and Sampling Plan

The establishment of SIEs was considered the intervention point for measuring immediate (level) and gradual (trend and persistence) changes in the time series. The sample period was from 2014 to 2023. The intervention occurred on January 1, 2019. This ensured that there was an equal duration of time before and after the intervention. Using long, balanced pre- and post-intervention segments is a crucial methodological recommendation for interrupted time-series analysis (ITSA) (Penfold & Zhang, 2013; Wagner et al., 2002). This approach maximizes the statistical power of the test and ensures an unbiased estimation of the standard errors of the residual noise term. It also avoids "artificially biased degrees of freedom" and unreliable significance tests that would result from a very short pre-intervention period (Linden, 2015; Shadish et al., 2002).

The treatment group consists of the 17 CSPE-SIE institutions and the control group consists of the 52 CSPE institutions that are not classified as SIEs and have individual assets

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exceeding R$2 billion (see Tables A1 and A2 for the list of institutions). The composition of the treatment and control groups remained the same before and after the event date to avoid non-random sampling bias in the treatment or control group, as noted by Peixoto et al. (2017). It is assumed that neither group was specifically affected by idiosyncratic changes independent of the event date, such that the trajectory of the outcome variable did not change to the point of ceasing to represent the counterfactual of the treatment group. The control group was constructed to resemble the treatment group, including both observed characteristics and the temporal trend of the variable as predictors.

3.2 Estimation Methods

An empirical-analytical approach was used, characterized by a focus on practical studies and technical, restorative, and incremental proposals concerned with the causal relationship between variables (Matias-Pereira, 2012). The models described in Table 3 were applied as analytical approaches.

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Table 3

Analytical approaches

Modeling	Test	Test description
Descriptive statistics	Normality and descriptive metrics	The Shapiro-Wilk test (1965) was used to perform normality tests on quantitative variables. Additionally, measures of skewness and kurtosis were calculated to evaluate the shape of the data distribution.
	Non-parametric: Kruskal-Wallis	Because the variables were not normally distributed, this test was used to assess whether there were statistically significant differences between the treatment and control groups, as well as between public and private sponsorship (Kruskal & Wallis, 1952).
	Spearman's correlation matrix	This test is suitable for non-normal data. It ensures robustness in the presence of outliers and asymmetric distributions (Zar, 1972).
Quantitative models for hypothesis testing	PERMANOVA	This determines whether there was a difference between the two groups (public vs. private sponsorship) for at least one of the variables (Anderson, 2017).
	DID	This estimates the direct causal effects of the event date. The main hypothesis of the model is that the time trajectory of the outcome variable for the control group represents what would have occurred with the treatment group had there been no intervention since the treatment induces the change in trajectory (Angrist & Pischke, 2009).
	DDD	This includes sponsorship predominance as a third dimension of comparison, assessing more complex interactions between treatment, time, and an additional characteristic. The models were fitted using robust linear regression, which is resistant to violations of the assumptions of normality and homoscedasticity of the residuals (Angrist & Pischke, 2009).
	PCA	This assesses the multivariate structure of the variables. PCA transforms correlated variables into principal components, which allows for the identification of patterns and clusters in the data (Jolliffe & Cadima, 2016).

DDD = differences-in-differences-in-differences; DID = differences-in-differences; PCA = principal component analysis; PERMANOVA = permutational multivariate analysis of variance.

Source: *Prepared by the authors.*

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Table 4 describes the selected test variables, specifications, analysis techniques, and expected trends.

Table 4
Variables – Parameters and trends for the control (C) and treatment (T) groups

Variable	Algorithm	Expected trends
PPAE (pension plan expenses)	Total pension plan administrative expenses	 Proportionality = higher costs for SIEs. PPAE increases by a higher percentage in the treatment group than in the control group.
AETA (PPAE/total assets)	Pension plan administrative expenses/total assets	 Greater governance leads to higher costs for SIEs. PPAE grows at a higher rate in the treatment group, given the increase in regulatory costs for SIEs, without a similar increase in total assets.
EPC (per capita administrative expenses)	PPAE/Total fund participants	 Administrative expenses grow at a higher rate in the treatment group; however, greater governance in SIEs generates more confidence and leads to new enrollments and less portability.
TA (total assets)	Total fund assets/benefit management assets	 Grows proportionally more in the treatment group, as greater governance generates confidence, leading to more contributions from participants.
SR (solvency ratio)	Coverage assets/actuarial reserves	 SIE solvency improves (reduction in deficit/increase in actuarial technical surplus) by a higher percentage than in the control group.
POP (fund population)	Number of participants	 Better governance enhances SIE credibility, attracting new members and reducing portability.

C = control; SIE = Systemically Important Entities; T = treatment.
Source: *Prepared by the authors.*

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4. RESULTS

4.1 Descriptive Analysis

4.1.1 Characteristics of CSPEs

Table 5 compares quantitative variables between the control and treatment groups. The p-value is significant for all variables (<0.001), most notably in POP (fund population), TA (total assets), PPAE (pension plan expenses), and EPC (per capita administrative expenses). In these variables, the treatment group has higher mean values than the control group. There is a highly significant different in AETA, where the treatment group has higher means than the control group, but with better solvency.

Table 5
Characteristics of closed supplementary pension entities (CSPEs) – Control and treatment groups

Variable	Control n = 520	Treatment n = 170	p-value*
POP (thousands)	24.13 (27.76)	64.78 (60.18)	< 0.001
TA (R$ billion)	4.45 (2.21)	35.68 (53.38)	< 0.001
PPAE (R$ billion)	0.02 (0.01)	0.09 (0.08)	< 0.001
AETA	0.00 (0.00)	0.01 (0.03)	0.016
EPC (R$)	1,697.89 (2,817.70)	2,423.55 (4,006.27)	< 0.001
SR	1.02 (0.11)	0.98 (0.14)	0.010

Notes: *The variables are described in Table 4. Values are presented as mean (standard deviation).*
** = Kruskal-Wallis rank sum tests.*
Source: *Prepared by the authors.*

4.1.2 Normality, skewness, and kurtosis

As expected, all dependent variables are skewed and do not follow a normal distribution, as evidenced by very low p-values from the Shapiro-Wilk test. They also exhibit striking patterns of high skewness and kurtosis (Table 6).

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Table 6
Characteristics of closed supplementary pension entities (CSPEs) – Normality and measures of skewness and kurtosis with data

Variable	Shapiro-Wilk p-value	Skewness	Kurtosis
POP	< 0.0001	2.396	5.461
TA	< 0.0001	5.873	39.362
PPEA	< 0.0001	3.893	16.562
AETA	< 0.0001	13.301	205.992
EPC	< 0.0001	4.631	22.801
SR	< 0.0001	0.065	10.944

Note: *The variables are described in Table 4.*
Source: *Prepared by the authors.*

The observed asymmetry is an expected characteristic of economic and financial time series (Fama, 1965; Mandelbrot, 1963). Variables representing flows, counts, or aggregates (such as POP and TA) and variables with a high frequency of outliers or shocks (such as financial returns or performance metrics) tend to exhibit fat-tailed distributions and asymmetry (Bollerslev, 1987; Hamilton, 1994).

Instead of treating asymmetry as a deviation from the norm, the econometric modeling recognizes and incorporates this intrinsic data characteristic. The primary methodological concern is ensuring that the model (e.g., ITSA or robust regression) is robust to non-normality in the residuals (Greene, 2018). Figure 1 shows the histograms of the indicated variables.

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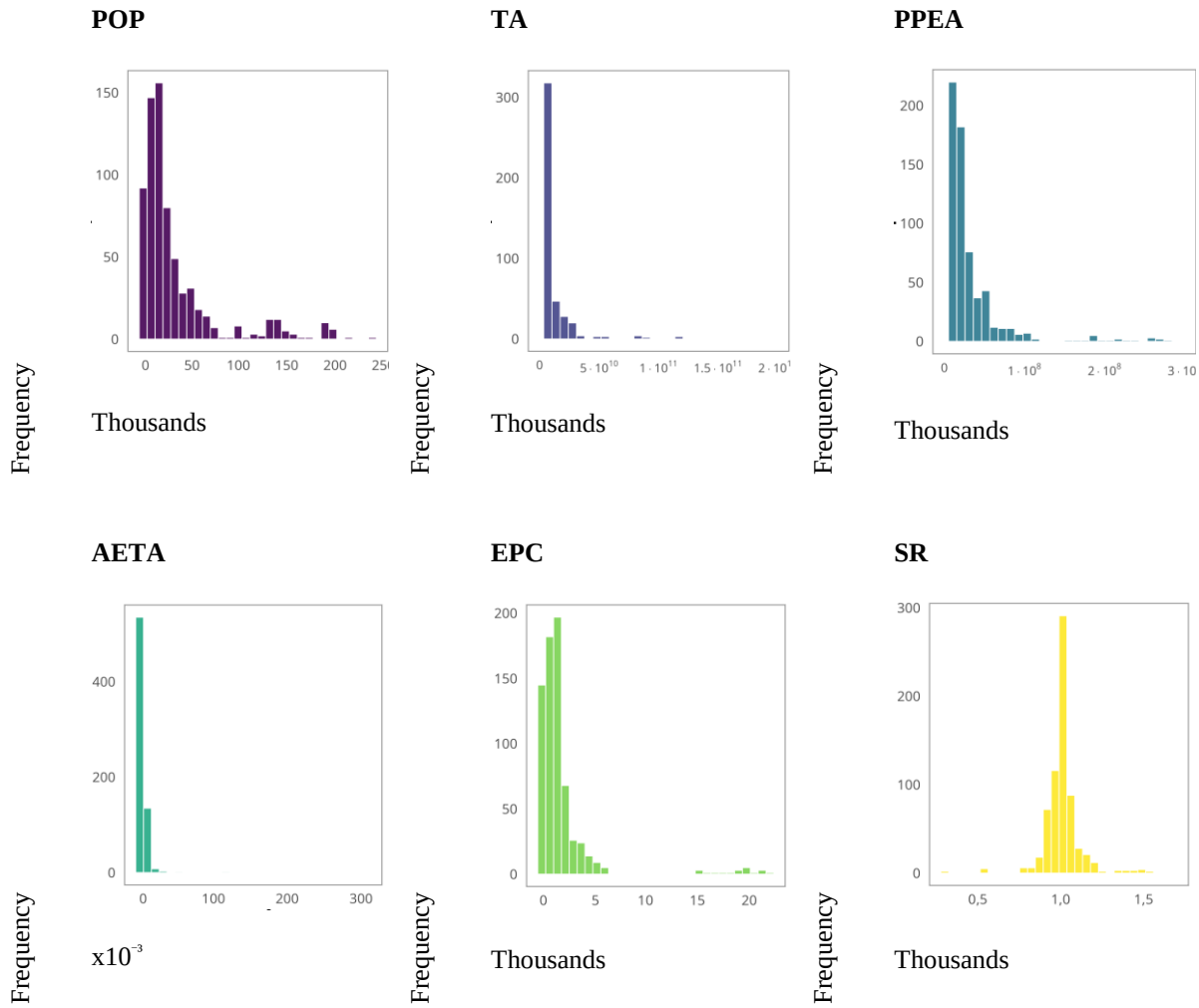

Figure 1 *Frequency distribution of the study variables.*
Note: *The variables are described in Table 4.*
Source: *Prepared by the authors.*

4.1.3 Spearman's correlation matrix

Table 7 summarizes the correlation patterns among the study's response variables. All correlations are significant ($p < 0.05$), except for the correlation between POP and SR (solvency ratio) ($p = 0.60$). Most variables exhibit weak correlations with one another (modulus less than 0.5). The strongest correlation, with a positive value of 0.752, is between PPAE and TA.

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Table 7
Spearman's correlation matrix

Variables	POP	AT	DEAPP	DAAT	DPC	IS
POP	1					
AT	0,345*	1				
DEAPP	0,353*	0,752*	1			
DAAT	-0,103*	-0,326*	0,279*	1		
DPC	-0,603*	-0,268*	0,451*	0,286*	1	
IS	0,002	-0,092*	-0,158*	-0,14*	-0,133*	1

** $p < 0.05$.*
Note: *The variables are described in Table 4.*
Source: *Prepared by the authors.*

4.2 Hypothesis Testing

4.2.1 Predominance of CSPE sponsorship – Public vs. private

To assess whether there was a multivariate difference in the set of variables between public and private sponsorship, permutational multivariate analysis of variance (PERMANOVA) was performed. PERMANOVA is a non-parametric, robust test considered an alternative to classical multivariate analysis of variance (MANOVA) because it does not require compliance with strict assumptions of multivariate normality or homogeneity of variances and covariances. PERMANOVA tests for differences in the positions of the centroids (i.e., the multivariate means) of the groups using a dissimilarity (distance) matrix and calculating significance via a permutation procedure (Anderson et al., 2008; Anderson, 2001). The test results demonstrated a statistically significant difference in the set of variables between the two groups with 10,000 permutations yielding a pseudo-F of 21.86 and a p-value of less than 0.001. Although PERMANOVA indicates whether there is a difference in the multivariate space, it does not specify the variable in which this difference manifests. Therefore, non-parametric univariate tests were subsequently performed to identify the variables responsible for the distinction between public and private sponsorship. Once the difference was indicated, non-parametric tests were applied to identify where the differences lay. Table 8 compares quantitative variables between groups with predominant sponsorship using the Kruskal-Wallis

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test. As can be seen from Table 8, the group with public sponsorship has higher mean values in TA, PPAE, and EPC, while the private group has a better SR.

Table 8
Predominance of sponsorship of closed supplementary pension entities (CSPEs) – Public vs. private

Variable	Public n = 320	Private n = 370	p-value*
POP (thousands)	33.51 (50.29)	34.70 (33.61)	< 0.001
TA (billions)	17.75 (42.12)	7.29 (8.13)	0.006
PPAE (billions)	0.05 (0.07)	0.02 (0.02)	< 0.001
AETA	0.01 (0.02)	0.00 (0.00)	< 0.001
EPC	2,946.60 (4,271.80)	951.33 (1,036.18)	< 0.001
SR	0.97 (0.14)	1.04 (0.09)	< 0.001

Notes: *The variables are described in Table 4. Values are presented as mean (standard deviation).*
***** *= Kruskal-Wallis rank sum tests.*
Source: *Prepared by the authors.*

4.2.2 DID and DDD models

Despite the non-normality, asymmetry, and kurtosis of the variables, the difference-in-differences (DID) and difference-in-differences-in-differences (DDD) analyses adjusted using the robust option in Stata 17 ensured reliable statistical inferences. Tables 9 and 10 present the detailed statistics of the DID and DDD models for the study variables, with 690 observations in each table. Table 9 for the DID model shows the effects of treatment, event_date, and event_treatment on the study variables. The DID model confirmed a positive effect of treatment on POP (coefficient = 38,459.49; $p < 0.001$), explaining 17.6% of the variance. The DID model was used to estimate the causal effect of an intervention in the treatment group while controlling for common time trends.

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Table 9

DID model by study variable

Variable		Coefficient	Standard error	t-value	P>|t|	Lower limit	Upper limit
POP	treatment	38,459.49	6,532.02	5.89	< 0.0001	25,634.34	51,284.64
	event_date	3,407.53	2,435.12	1.40	0.162	-1,373.65	8,188.72
	event_treatment	4,373.53	9,528.13	0.46	0.646	-14,334.30	23,081.32
	_cons	22,430.50	1,255.92	17.86	< 0.0001	19,964.59	24,896.41
F-test [F(3, 686) = 26.35, Prob > F = 0.0000]							
R^2 = 0.1763							
Root MSE = 38,334.00							
TA	treatment	25,500,000,000	4,650,000,000	5.49	< 0.0001	16,400,000,000	34,700,000,000
	event_date	1,530,000,000	183,000,000	8.38	< 0.0001	1,170,000,000	1,890,000,000
	event_treatment	11,400,000,000	8,130,000,000	1.41	0.160	-4,500,000,000	27,400,000,000
	_cons	3,680,000,000	108,000,000	34.05	< 0.0001	3,470,000,000	3,890,000,000
F-test [F(3, 686) = 43.83, Prob > F = 0.0000]							
R^2 = 0.2174							
Root MSE = 26,000,000,000							
PPAE	treatment	64,900,000	8,723,626	7.43	< 0.0001	47,700,000	82,000,000
	event_date	3,208,865	1,012,507	3.17	0.002	1,220,881	5,196,849
	event_treatment	6,067,405	13,000,000	0.47	0.640	-19,000,000	31,600,000
	_cons	16,100,000	687,546	23.35	< 0.0001	1,470,000	17,400,000
F-test [F(3, 686) = 39.96, Prob > F = 0.0000]							
R^2 = 0.3188							
Root MSE = 43,000,000							
AETA	treatment	0.0127	0.0050	2.56	0.011	0.0030	0.0224
	event_date	-0.0008	0.0002	-3.89	< 0.0001	-0.0012	-0.0004
	event_treatment	-0.0119	0.0050	-2.38	0.018	-0.0216	-0.0021
	_cons	0.0045	0.0002	25.27	< 0.0001	0.0042	0.0049
F-test [F(3, 686) = 7.87, Prob > F = 0.0000]							
R^2 = 0.0657							
Root MSE = 0.0162							
EPC	treatment	919.69	498.88	1.84	0.066	-59.82	1,899.19
	event_date	227.64	247.41	0.92	0.358	-258.12	713.41
	event_treatment	-0.01	662.33	-0.59	0.558	-1,688.48	912.38
	_cons	-388.05	171.13	9.26	< 0.0001	1,248.07	1,920.06
F-test [F(3, 686) = 1.91, Prob > F = 0.1271]							
R^2 = 0.0109							

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Root MSE = 3,154.30							
SR	treatment	-0.0491	0.0181	-2.70	0.007	-0.0847	-0.0134
	event_date	-0.0068	0.0100	-0.68	0.497	-0.0265	0.0129
	event_treatment	0.0214	0.0233	0.92	0.358	-0.0243	0.0671
	_cons	1.0196	0.0084	121.40	< 0.0001	1.0031	1.0361
F-test [F(3, 686) = 3.63, Prob > F = 0.0127]							
R^2 = 0.0201							
Root MSE = 0.1204							

Note: *The variables are described in Table 4.*
DID = differences-in-differences; MSE = mean squared error.
Source: *Prepared by the authors.*

Table 10
DDD Model – Effect of sponsorship on the variables

Variable		Coefficient	Standard error	t-value	P>|t|	Lower limit	Upper limit
POP	treatment	41,819.35	6,451.68	6.48	< 0.0001	29,151.87	54,486.83
	event_date	3,407.53	2,304.57	1.48	0.140	-1,117.35	7,932.41
	sponsorship	13,814.49	2,301.75	6.00	< 0.0001	9,295.145	18,333.84
	event_treatment	18,809.18	11,815.29	1.59	0.110	-4,389.40	42,007.77
	ddd_interaction_spons.	-40,901.00	11,636.59	3.51	< 0.0001	-63,748.80	-18,053.30
	_cons	14,194.94	1,501.65	9.45	< 0.0001	11,246.54	17,143.33
F-test [F(5,684) = 40.71, Prob > F = 0.0000]							
R^2 = 0.2105							
Root MSE = 37,585.00							
TA	treatment	24,000,000,000	4,420,000,000	5.64	< 0.0001	16,200,000,000	33,600,000,000
	event_date	1,530,000,000	201,000,000	7.62	< 0.0001	1,140,000,000	1,920,000,000
	sponsorship	-2,600,000,000	1,000,000,000	-2.57	0.010	-4,500,000,000	-610,000,000
	event_treatment	18,700,000,000	11,300,000,000	1.66	0.097	-3,400,000,000	40,800,000,000
	ddd_interaction_spons.	-21,000,000,000	10,300,000,000	-2.00	0.046	-41,000,000,000	-330,000,000
	_cons	5,210,000,000	611,000,000	8.53	< 0.0001	4,010,000,000	6,410,000,000
F-test [F(5,684) = 60.14, Prob > F = 0.0000]							
R^2 = 0.2360							
Root MSE = 26,000,000,000							
PPEA	treatment	61,200,000	8,197,855	7.47	< 0.0001	45,100,000	77,300,000
	event_date	3,208,865	921,475	3.48	0.001	1,399,606	5,018,124

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	sponsorship	-15,000,000	2,044,582	-7.30	< 0.0001	-19,000,000	-11,000,000
	event_treatment	16,500,000	16,900,000	0.98	0.327	-17,000,000	49,600,000
	ddd_interaction_spons.	-30,000,000	15,100,000	-1.96	0.050	-59,000,000	53,592
	_cons	24,900,000	1,455,396	17.14	< 0.0001	22,100,000	27,800,000
F-test [F(5,684) = 38.86, Prob > F = 0.0000] R^2 = 0.3566 Root MSE = 43,000,000							
AETA	treatment	0.0115	0.0047	2.46	0.014	0.0023	0.0207
	event_date	-0.0008	0.0002	-3.65	< 0.0001	-0.0012	-0.0004
	sponsorship	-0.0047	0.0011	-4.45	< 0.0001	-0.0068	-0.0027
	event_treatment	-0.0124	0.0053	-2.34	0.020	-0.0228	-0.0020
	ddd_interaction_spons.	0.0015	0.0014	1.14	0.255	-0.0011	0.0042
	cons	0.0073	0.0007	10.87	< 0.0001	0.0060	0.0087
F-test [F(5,684) = 16.93, Prob > F = 0.0000] R^2 = 0.0835 Root MSE = 0.0161							
EPC	treatment	428.66	480.45	0.89	0.373	-514.6736	1,371.99
	event_date	227.64	231.59	0.98	0.326	-227.0635	682.35
	sponsorship	-2,018.94	259.56	-7.78	< 0.0001	-2,528.563	-1,509.32
	event_treatment	-594.82	815.53	-0.73	0.466	-2196.068	1,006.42
	ddd_interaction_spons.	585.86	663.35	0.88	0.377	-716.5919	1,888.31
	_cons	2,787.66	278.92	9.99	< 0.0001	2,240.023	3,335.30
F-test [F(5,684) = 16.40, Prob > F = 0.0000] R^2 = 0.1021 Root MSE = 3,009.7							
SR	treatment	-0.0370	0.0175	-2.11	0.035	-0.0714	-0.0026
	event_date	-0.0068	0.0010	-0.68	0.394	-0.0264	0.0128
	sponsorship	0.0495	0.0103	4.81	< 0.0001	0.0293	0.0698
	event_treatment	-0.0002	0.0248	-0.01	0.994	-0.0489	0.0485
	ddd_interaction_spons.	0.0611	0.0256	2.39	0.017	0.0109	0.1113
	_cons	0.9900	0.0117	85.02	< 0.0001	0.9672	1.0129
F-test [F(5,684) = 11.58, Prob > F = 0.0000] R^2 = 0.785 Root MSE = 0.1169							

Note: *The variables are described in Table 4.*
DDD = differences-in-differences-in-differences; MSE = mean squared error.
Source: *Prepared by the authors.*

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As shown in Table 9, the intercept is statistically significant in nearly all of the models, except for the EPC model. This finding is expected and indicates that the mean value of the dependent variable for the control group in the initial period is not zero. The significance of _cons confirms the robustness of the model's baseline estimate. For POP, for example, the _cons value of 22,430.5 ($p < 0.0001$) indicates that the average size of the control group population before regulation was approximately 22,430 participants. The model explains 17.63% of the total variance. However, the DID effect (event_treatment) was not statistically significant for POP (event_treatment = 4,373.528, $p = 0.646$). This corroborates the criticism that the regulatory event would not cause an immediate impact on the participant population, which tends to grow inertially. The DID effect was significant (and negative) only for the AETA variable (event_treatment = -0.01186; $p = 0.018$), suggesting a reduction in the deficit for the treatment group following the regulation.

To assess whether the effect of the regulation differed between publicly and privately sponsored CSPEs, the DDD model was applied (see Table 10). The central focus is the triple interaction coefficient (ddd_interaction_spons.), which measures the difference in the DID effect between the two groups. The DDD model showed significant negative triple-difference interactions for POP (event_treatment = -40,901, $p < 0.0001$), TA (event_treatment = -2.1E+10, $p = 0.046$), and PPAE (event_treatment = -3E+07, $p = 0.05$). This suggests that the impact of the regulation on publicly sponsored CSPEs was significantly smaller than on privately funded CSPEs. This indicates that publicly sponsored CSPEs were more sensitive to the regulation in certain dimensions, as observed in Table 10.

4.2.3 Principal component analysis

Principal component analysis (PCA) was used to summarize the correlations among the financial and constituent variables of the CSPEs and to identify patterns of differentiation

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between publicly and privately sponsored entities. As shown in Table 11, the first two principal components explained 63.5% of the total variance in the data, with 42.4% explained by component 1 (PC1) and 21.1% by component 2 (PC2).

Table 11
PCA results – Contribution of variables

Variable	PC1	PC2	Dimension 3	Dimension 4	Dimension 5
POP	0.849	-0.177	-0.024	0.204	0.451
AT	0.929	0.162	-0.012	0.03	-0.305
PPAE	0.956	0.195	0.073	0.089	-0.094
AETA	-0.090	0.038	0.942	0.321	-0.022
EPC	-0.065	0.839	0.195	-0.471	0.177
SR	-0.187	0.683	-0.315	0.632	-0.001

Note: *The variables are described in Table 4.*
PC1 = component 1; PC2 = component 2; PCA = principal component analysis.
Source: *Prepared by the authors.*

The criterion of eigenvalues greater than 1 (Kaiser's criterion) was used for component selection. Additionally, a percentage of 63.5% is considered sufficient to represent the multidimensional structure of a dataset in social and management studies. Authors such as Hair et al. (2009) and Johnson and Wichern (2007) accept values above 60% and 50%, respectively, depending on the complexity of the data. The percentage of variance explained by each component (42.4% and 21.1%, respectively) is derived from its respective eigenvalue. The eigenvalue of each component represents the amount of total sample variance explained by that axis. The components are interpreted based on the factor loadings (correlations) presented in Table 11.

PC1 – Size and financial capacity dimension: PC1 exhibited high positive loadings for TA (0.929), PPAE (0.956), and POP (0.849). This indicates that PC1 is a dimension of scale and financial capacity. CSPEs with high PC1 scores are characterized by a larger operational size and a greater volume of assets under management.

PC2 – Efficiency and financial balance dimension: PC2 was strongly influenced by SR (0.683) and EPC (0.839). The positive coefficient for EPC ($+0.839$) indicates that an increase

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in PC2 scores is associated with higher administrative costs per participant. This may reflect inefficiency, higher-quality services, or greater management complexity. The positive coefficient for SR (0.683) indicates a better balance between assets and liabilities. Therefore, CP2 constitutes an efficiency or cost-benefit dimension, where higher values represent CSPEs with better solvency and higher costs per participant.

The low (or slightly negative) correlation between size (PC1) and efficiency (PC2) variables suggests a trade-off. The separation into orthogonal axes shows that being large (high PC1) does not necessarily imply greater efficiency or solvency (high PC2).

The scatter plot of the first two components (Figure 2) clearly separates publicly and privately sponsored CSPEs. Publicly sponsored entities (in green) are concentrated primarily in regions associated with larger size and higher expenses (high PC1), but lower individual efficiency (lower PC2). In contrast, privately sponsored entities (in blue) are distributed closer to the origin, suggesting smaller structures and a better solvency-to-per-participant expense ratio. Taken together, these results reinforce the interpretation of the DID and DDD models. SIEs, particularly those with public sponsorship, are larger and more complex but have higher operating costs and lower average solvency. Thus, PCA confirms the trade-off pattern between scale and efficiency identified throughout the causal analyses.

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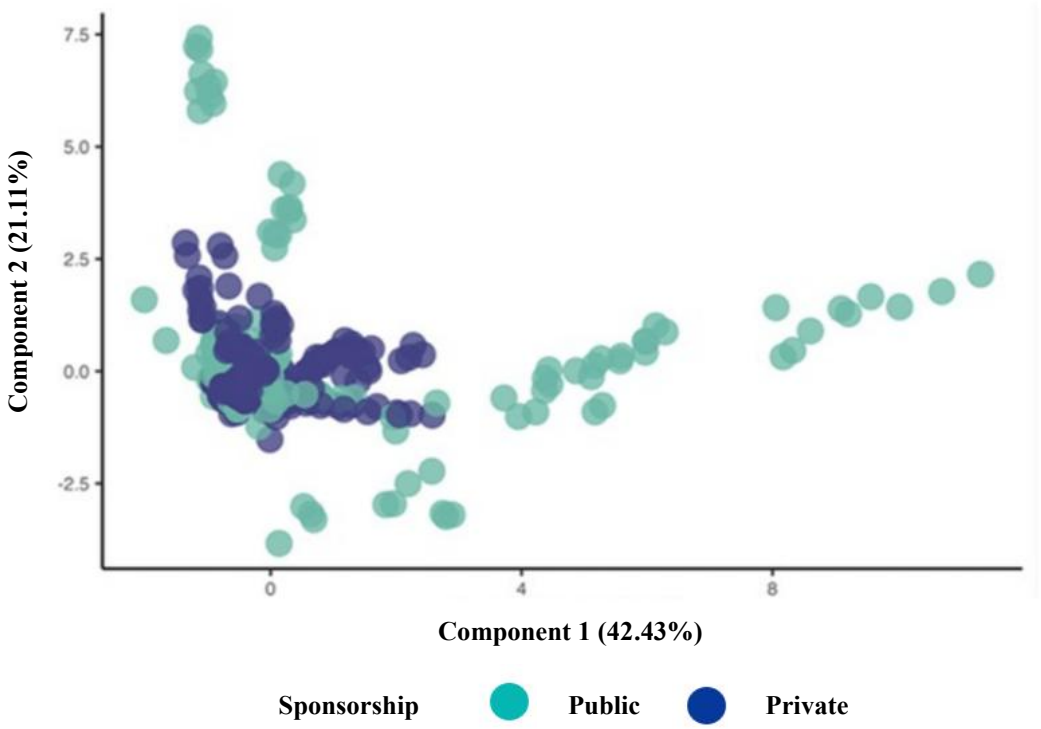

Figure 2 *Principal component analysis – Public vs. private sponsorship*
Source: *Prepared by the authors.*

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5. CONCLUSIONS

This study aimed to provide empirical evidence of the extent to which regulatory proportionality applied to CSPE-SIEs in Brazil reduces systemic risk, improves solvency, and balances private pension fund freedom (self-regulation) and state intervention (regulation). Additionally, the study examined how regulatory proportionality affects publicly and privately sponsored entities differently, including those classified and not classified as SIEs.

Despite imposing additional costs on pension funds, there are indications that regulatory proportionality for SIEs has been beneficial to the system.

The benefits of the requirement for CSPE-SIEs to implement measures ensuring manager qualifications, establishing risk management mechanisms, and increasing independent oversight through audit committees and independent auditors outweighed the incremental costs and had a greater impact than the trend of improving the SR. Among publicly sponsored CSPEs, 50% were insolvent in 2023, while among privately sponsored CSPEs, this indicator was 30%. There was significant asset growth, and the EPC and AETA improved, with a stronger effect on privately sponsored CSPEs. Publicly sponsored funds are more sensitive to regulation.

For publicly sponsored CSPEs, the results suggest that these entities manage pension plan administrative expenses less efficiently than privately sponsored ones, despite having much higher average total assets. They reported a higher volume of expenses relative to assets and per capita expenses 3.1 times higher than those of privately sponsored funds.

5.1 Practical and Theoretical Implications

This research reveals the importance of closed-end supplementary pension plans from economic and social perspectives. Evidence suggests that this segment requires robust governance to balance the principal-agent relationship and protect participants' rights and savings. This research has the following implications:

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5.1.1 For researchers

Although this is a current and relevant topic for society, academia, and the private pension sector, no empirical studies were found on the impact of applying regulatory proportionality to pension funds from the perspective of sponsorship predominance. This study addresses this gap in the literature by evaluating regulatory outcomes. The combined use of Kruskal-Wallis, Spearman's correlation matrix, DID, DDD, and PCA strengthens the robustness of the results and offers a replicable model for studies in different contexts and geographies.

5.1.2 For regulators

The increase in compliance costs was minimal. If the regulatory proportionality applied to CSPE-SIE entities is extended to all publicly sponsored entities, it certainly will not be significant enough to overcome their managers' rational apathy regarding regulatory costs. Therefore, it is recommended that PREVIC analyze the opportunity to extend the requirement for these prudential measures to entities with predominantly public sponsorship that have larger assets and higher risks. This would better protect the interests of participants, sponsors, and the economy.

5.2 Limitations and Guidelines for Future Research

All observations were collected from the websites of the CSPEs and PREVIC, and data completeness was ensured.

To advance our understanding of the regulatory framework applied to CSPEs, it is necessary to investigate its practical effects, gaps, and impacts on risk mitigation. This will help eliminate omissions or overlaps in the regulatory environment while balancing self-regulation within the sector and state regulation. Therefore, it is suggested that researchers investigate

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whether there are similarities between the regulatory frameworks of countries with different predominances of public or private sponsorship and whether there are opportunities to adjust Brazilian regulation. Additionally, it is recommended that researchers assess whether the principles promoted by the OECD and the World Bank enhance the governance of pension funds in Brazil, or if they constitute political action aimed at influencing the policies of underdeveloped or developing countries by imposing the rules and guidelines of wealthy nations.

5.3 Final Considerations

A suitable regulatory framework enhances the credibility of the private pension system, maintains participants' confidence by providing greater flexibility in retirement decisions, and generates long-term savings for the economy while reducing systemic risk. However, there are long-term economic effects that impact pension funds and put pressure on the system. For example, increased life expectancy can make it difficult to meet actuarial targets. PREVIC's introduction of regulatory proportionality helps protect assets and preserve the social and economic importance of supplementary pensions.

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Conceptualization: lead;
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Formal analysis: lead;
Methodology: lead;
Project management: lead;
Resources: lead;
Supervision: lead;
Validation: lead;
Visualization: lead;
Writing – original draft: lead;
Writing – revision and editing: equal.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The entire dataset supporting the results of this study can be made available upon request to the authors.

GENERATIVE AI DISCLOSURE

The authors declare that they did not use generative artificial intelligence at any stage of producing this manuscript, including research, writing, data analysis, formulas, and creation of graphic elements.

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APPENDIX

Table A1

CSPEs comprising the treatment group with data as of December 2023

Treatment group (SIE)	CSPE Acronym	Sponsorship	Participants (n)	Total assets (R$ million)
1. Caixa de Previdência dos Funcionários Banco do Brasil	PREVI/BB	Public	192,782	287,151
2. Fundação Petrobras de Seguridade Social	PETROS	Public	129,653	130,463
3. Fundação dos Economiários Federais	FUNCEF	Public	139,833	115,768
4. Fundação Cesp	FUNCESP	Private	55,529	49,205
5. Fundação Itaú Unibanco – Previdência Complementar	ITAÚ UNIBANCO	Private	50,886	32,972
6. Fundação Vale do Rio Doce de Seguridade Social	VALIA	Private	138,963	30,696
7. Fundação Sistel de Seguridade Social	SISTEL	Private	23,062	22,621
8. Fundo Banespa de Seguridade Social	BANESPREV	Private	28,311	29,703
9. Fundação Forluminas de Seguridade Social	FORLUZ	Public	23,125	21,129
10. Real Grandeza – Fundação de Previdência e Assistência Social	REAL GRANDEZA	Public	12,449	18,893
11. Fundação de Assistência e Previdência Social do BNDES	FAPES	Public	5,082	16,602
12. Fundação Atlântico de Seguridade Social	FATL	Private	22,966	13,369
13. Fundação Copel de Previdência e Assistência Social	COPEL FOUNDATION	Public	21,583	14,407
14. Postalis – Instituto de Previdência Complementar	POSTALIS	Public	185,847	20,411
15. Fundação de Previdência Complementar do Servidor Público	FUNPRESP-EXE	Public	118,040	9,273
16. Fundação de Previdência Complementar do Estado de São Paulo	SP-PREVCOM	Public	49,921	3,372
17. Fundação de Previdência Complementar do Servidor Público Federal do Poder Judiciário	FUNPRESP-JUD	Public	33,004	3,330
Total			**1,231,036**	**819,365**

CSPEs = closed supplementary pension entities; SIEs = Systemically Important Entities.

Source: *Prepared by the authors based on data from the National Superintendence of Supplementary Pension Plans (PREVIC, 2024).*

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Table A2

CSPEs comprising the control group with data as of December 2023

Treatment group (SIE)		CSPE Acronym	Sponsorship	Participants (m)	Total assets (R$ million)
1.	Previdência Usiminas	USIMINAS PENSION PLAN	Private	35,663	10,554
2.	Telos – Fundação Embratel de Seguridade Social	TELOS	Private	14,605	10,215
3.	Fundação Chesf de Assistência e Seguridade Social	FACHESF	Public	18,037	12,357
4.	Ceres Fundação de Seguridade Social	CERES	Public	22,361	11,311
5.	HSBC Fundo de Pensão	MULTIBRA	Private	54,781	9,729
6.	Economus Instituto de Seguridade Social	ECONOMUS	Public	18,356	11,124
7.	Fundação Banco Central de Previdência Privada	CENTRUS	Public	2,474	6,732
8.	Fundação Família Previdência	FAMÍLIA PREVIDÊNCIA	Public	18,370	6,802
9.	Fundo de Pensão do Banco do Brasil	BB PENSION	Private	238,686	9,022
10.	Visão Prev Sociedade de Previdência Complementar	VISÃO PREV	Private	21,412	8,345
11.	Fundação Rede Ferroviária de Seguridade Social	REFER	Public	24,594	10,193
12.	Multiprev Fundo Múltiplo de Pensão	MULTIPREV	Private	71,181	11,596
13.	Serpros Fundo Multipatrocinado	SERPROS	Public	12,751	8,347
14.	Caixa Beneficente dos Empregados da CSN	CBS	Private	34,814	6,420
15.	Fundação Banrisul de Seguridade Social	BANRISUL/FBSS	Public	18,477	6,855
16.	Fundação Previdenciária IBM	IBM	Private	9,114	6,068
17.	Fundação Eletrobras de Seguridade Social	ELETROS	Public	5,247	5,854
18.	Caixa de Previdência dos Funcionários do BNB	CAPEF	Public	13,346	6,854
19.	Funbep – Fundo Pensão Multipatrocinado	FUNBEP	Private	6,342	7,596
20.	Previ-GM Sociedade de Previdência Privada	PREVI-GM	Private	21,826	5,220
21.	Fundação Itaipu BR de Previdência e Assistência Social	FIBRA	Private	4,224	6,308
22.	Previnorte – Fundação de Previdência Complementar	PREVINORTE	Public	5,929	4,660
23.	Gerdau – Sociedade de Previdência Privada	GERDAU	Private	19,614	4,604
24.	Santander – Sociedade de Previdência Privada	SANTANDERPREV	Private	25,029	4,927
25.	BRF Previdência	BRF PENSION	Private	47,552	4,655
26.	Nucleos Instituto de Seguridade Social	NUCLEOS	Public	4,974	4,594
27.	Fundação Libertas de Seguridade Social	LIBERTAS FOUNDATION	Public	20,692	4,710
28.	Instituto Infraero de Seguridade Social	INFRAPREV	Public	10,912	4,262
29.	Fundação de Seguridade Social Braslight	BRASLIGHT	Private	9,544	3,529
30.	Fundação de Seguridade Social Arcelormittal BR	FUNSSEST	Private	12,162	4,188
31.	Citiprev EFPC	CITIPREV	Private	6,864	4,313
32.	Fundação Eletrosul de Previdência e Assistência Social	ELOS	Public	5,063	4,777
33.	Vexty	VEXTY	Private	17,476	4,427

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34.	Fundação Celesc de Seguridade Social	CELOS	Public	13,507	4,626
35.	Unilever – Sociedade de Previdência Privada	UNILEVERPREV	Private	15,166	4,045
36.	Multipensions Bradesco – Fundo Multipatrocinado de Previdência Privada	MULTIPENSIOS	Private	66,857	4,380
37.	Fundação Sabesp de Seguridade Social	SABESPPREV	Public	20,389	4,463
38.	Quanta – Previdência Unicred	QUANTA	Private	190,384	6,177
39.	Fundação Nestlé de Previdência Privada	FUNEPP	Private	25,371	3,951
40.	Embraer Prev – Previdência Complementar	EMBRAER PREV	Private	21,468	4,801
41.	Fundação Geap Previdência	VIVA	Private	57,066	3,009
42.	Volkswagen Previdência Privada	VWPP	Private	31,355	3,517
43.	Fundação Itausa Industrial	ITAUSAINDL	Private	6,387	3,620
44.	Metrus Instituto de Seguridade Social	METRUS	Public	12,368	4,027
45.	Itaú Fundo Multipatrocinado	IFM	Private	42,069	4,108
46.	Regius Sociedade. Civil de Previdência Complementar	REGIUS	Public	6,877	3,885
47.	Icatu Fundo Multipatrocinado	ICATUFMP	Private	37,040	3,184
48.	Fundação de Previdência dos Servidores do IRB	PREVIRB	Private	1,987	3,034
49.	Fundação Codesc de Seguridade Social	FUSESC	Public	6,765	3,005
50.	Multipla – Multiempresas de Previdência Complementar	MULTIPLA	Private	23,314	2,762
51.	Instituto Conab de Seguridade Social	CIBRIUS	Public	4,537	2,945
52.	Prevdow – Sociedade de Previdência Privada	PREVDOW	Private	4,006	2,684
Total				**1,439,385**	**303,371**

CSPEs = closed supplementary pension entities; SIEs = Systemically Important Entities.

Source: *Prepared by the authors based on data from the National Superintendence of Supplementary Pension Plans (PREVIC, 2024).*

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