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ORIGINAL ARTICLE

Discretion and assumption choices for closed supplementary pension plans

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ABSTRACT

This study investigates whether defined benefit (DB) plans and variable contribution (VC) plans of Brazilian closed supplementary pension funds (CSPF) present indications of discretion in the assumptions used in actuarial evaluations. Even though discretionary behavior by managers has been widely analyzed by the literature, the subject of DB and VC plans has been explored very little, mainly from a regulatory point of view. This study contributes in terms of research regarding the Brazilian supplementary pension fund market by providing evidence of possible discretionary actions by managers in terms of the assumptions used in DB and VC plans. The findings offer elements that the National Council on Supplementary Pensions (CNPC) can use to revise or create more rigorous parameters that limit the use of assumptions as instruments of deliberate alterations regarding the solvency of these plans. This work features econometric models elaborated based on panel and multinomial logit data, in order to verify whether the assumptions of DB and VC plans for companies traded in the Brazilian stock market are influenced by four groups of explanatory variables. It evaluates whether a given actuarial assumption can be managed to compensate the behavior of another actuarial assumption; whether some characteristics of plans and the sponsoring companies can motivate interference in the selection of assumptions; and whether increments in the Special System for Settlement and Custody (*Sistema Especial de Liquidação e de Custódia* – SELIC) rate are linked to assumption choices which reduce the mathematical provisions. The results indicate that it is not possible to discard that the assumptions used in DB and VC plans are the subject of discretionary actions made by managers. There is evidence that assumptions regarding real interest rates, the benefit capacity factors and overall mortality tables are being managed to alter the solvency situation of these plans to a greater or lesser extent.

Keywords: discretion, DB plans, VC plans, assumptions.

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Discricionariedade e escolhas de premissas nos planos de previdência complementar fechados

RESUMO

Este estudo investigou se os planos benefício definido (BD) e contribuição variável (CV) das entidades fechadas de previdência complementar (EFPC) brasileiras apresentam indícios de discricionariedade nas escolhas de suas premissas utilizadas nas avaliações atuariais. Embora a conduta discricionária de gestores já tenha sido amplamente analisada na literatura, essa temática foi muito pouco explorada em relação às premissas dos planos BD e CV, principalmente sob o enfoque regulatório. O estudo contribui com a pesquisa e o mercado de previdência complementar brasileiro ao trazer evidências de uma possível ação discricionária de gestores sobre as premissas dos planos BD e CV. Os achados trazem elementos para que o Conselho Nacional de Previdência Complementar (CNPC) possa revisar ou criar parâmetros mais rigorosos, que limitem o uso das premissas como instrumentos de alterações deliberadas na situação de solvência dos planos. Foram elaborados modelos econométricos de dados em painel e logit multinomiais, com o intuito de verificar se as premissas dos planos BD e CV das empresas que negociam na Bolsa de Valores brasileira são influenciadas por quatro conjuntos de variáveis explicativas. Avaliou-se se determinada premissa atuarial poderia ser gerenciada para compensar o comportamento de outra premissa atuarial; se algumas características dos planos e das empresas patrocinadoras poderiam motivar interferências nas escolhas das premissas; e se incrementos na taxa do Sistema Especial de Liquidação e de Custódia (SELIC) estariam atrelados às escolhas de premissas que reduzem as provisões matemáticas. Os resultados indicaram que não é possível descartar que as premissas dos planos BD e CV estejam sendo alvo da ação discricionária de gestores. Há evidências de que as premissas da taxa real de juros, do fator de capacidade de benefício e da tábua de mortalidade geral estão sendo gerenciadas para alterar a situação de solvência dos planos em maior ou menor grau.

Palavras-chave: *discricionariedade, planos BD, planos CV, premissas.*

1. INTRODUCTION

A closed supplementary pension plan, in its classic form, is a type of voluntary pension plan, in which employees of private or state-owned companies, or public servants (participants) make contributions to a pension plan administered by a closed supplementary pension fund (CSPF) which normally receives contributions from the employer (sponsor) (Mello et al., 2019).

There are three types of plans that can be offered by a CSPF, namely: a) a defined contribution (DC) plan; b) a defined benefit (DB) plan; and c) a variable contribution (VC) plan (Teixeira et al., 2022). The technical pronouncement CPC 49 of the Accounting Pronouncement Committee – Accounting and Accounting Reports of Pension Plan Benefits, a norm correlated with International Accounting Standards (IAS) 26 – Accounting and Reporting by Retirement Benefit Plans, address each one of these plan types:

a) **DC Plans:** which are characterized as possessing a defined cost to maintain individual reserves, formed by the contributions of the participants, the sponsor, and the income from the plan`s financial applications, with the post-employment benefit generally being for a fixed time period (which can be a single payment) which will only be known at the moment of retirement (Teixeira, 2023);

b) **DB Plans:** which maintain a capitalized mutual fund, in which the post-employment benefit is known beforehand, with this being constituted by contributions by the participants and the sponsor, based on assumptions which should be sufficient to guarantee a usual lifetime income (Asthana, 1999; Kisser et al., 2017); and

c) **VC Plans:** which have DC characteristics during the accumulation phase, and DB characteristics during the benefit payment phase. According to Azambuja (2021) and Azambuja & Campani (2019), one of the main attributes of VC plans is the guarantee of a minimum pension in the DB portion of the plan.

Since DB and VC plans ensure the possibility of lifelong income for their active, inactive, and pensioner participants, they are subject to actuarial risks derived from assumptions related to the plans` income or actuarial targets, the life expectancy of their participants, family composition, and level of salary growth, etc. (Asthana, 1999; Bergstresser et al., 2006); which do not occur in DC plans, which are strictly financial, that is, free from actuarial risks (Teixeira et al., 2022). In this way,

if one or more of the assumptions proves incorrect over the long term, DB and VC plans can incur deficits, which can lead to the penalizing of active, inactive, and pensioner participants with extraordinary contributions to reestablish balance in these plans (Azambuja & Campani, 2022; Teixeira et al., 2023).

In addition, there is a debate in the literature about the possibility of sponsor and pension fund managers affecting the earnings of DB and VC plans, given that many of the demographic, economic, and financial assumptions, among others, used in the actuarial evaluations are subject to greater or lesser degrees of discretion (Asthana, 1999; Bergstresser et al., 2006; Billings et al., 2016; Kisser et al., 2017; O'Brien, 2020; Teixeira, 2023).

In this sense, in order to gauge the possible discretionary actions of these managers, this study analyzes the behavior of several of the assumptions that are utilized in actuarial valuations of supplementary pension plans, namely real interest rates, overall mortality tables, and the factors used to determine the real value over the benefit period (benefit capacity factors), which possess varying levels of discretion as permitted by the determinations of regulatory bodies.

In the case of real interest rates, Resolution No. 30 of the National Council on Supplementary Pensions (CNPC Resolution No. 30, 2018) announced that a CSPF can adopt a real annual interest rate limited to an interval between 70% of the rate parameter defined based on the average of the daily interest rate term structures of the past five years, based on federal public bonds indexed to the Broad Consumer Price Index (IPCA), whose midpoint is closest to the duration of the liability of the plan in question, and 0.4% above this parameter. In any event, if the CSPF intends to use an annual real interest rate outside the established interval, it needs to send a specific technical study requesting authorization from the National Superintendency for Supplementary Pensions (PREVIC).

In relation to overall mortality tables, Resolution No. 23 of the National Superintendency for Supplementary Pensions (Resolution PREVIC n. 23, 2023) determines that plans adopt the reference tables "AT-2000 basic – M" for the male sex and "AT-2000 basic – F" for the female sex. In other words, this means that CSPFs can freely choose tables with greater longevity as references for their plans. On the other hand, the same resolution only permits the use of tables that represent lower life expectancy in relation to the reference tables when the actuary responsible for the plan issues a specific report and the administrator responsible for the benefit plan agrees to this possibility.

Finally, the benefit capacity factor is the only assumption without any kind of pre-established regulatory limit (Teixeira, 2023). This is an assumption that varies between 0 and 1 and estimates the loss of purchasing power of the conceded benefits during an interval of time, which is generally 1 year. The closer to 1 the capacity factor is, the lower the expected inflation, with the opposite being true as well (Benelli et al., 2015).

Thus, the objective of this study is to investigate whether DB and VC plans in Brazilian CSPFs present indications of discretion in the selection of the assumptions utilized in actuarial evaluations. This analysis is important, because if these assumptions are not being selected following the real needs of these plans, this may mean that managers in the sponsors and CSPFs could be adopting agency behavior.

In terms of this study's limitations, we may cite the fact that it is not possible to clearly separate discretionary actions from non-discretionary actions in the selection of the assumptions used in actuarial evaluations. The evidence of possible discretionary behavior is based on the motivations raised by the literature on this subject.

In addition, this study does not evaluate real salary growth. This is an assumption that measures the estimated real growth rate in the salaries of participants in the sponsors which may have relevant implications in terms of the plans' mathematical provisions and costs (Benelli et al., 2015). Thus, the results found in this study are probably influenced by the absence of this variable.

2. THEORETICAL REFERENCES

2.1. Agency Theory

According to Jensen and Meckling (1976), agency theory was elaborated to explain the conflict of interests that exists between the owners of capital (principals) and the managers (agents) contracted to execute services that involve the concession of decision-making power. Thus, it is believed that if the parties in this relationship maximize their economic utility, agents will not always follow the interests of the principal, which is characterized as agency conflict (Black et al., 2020).

This situation occurs because the administrators can favor strategies in the corporate environment, which increase their career prospects, remuneration, and non-pecuniary benefits, instead of maximizing the value of

these firms, which is in the interest of the business owners (Koprowski et al., 2021).

According to Teixeira et al. (2022), agency behavior can also be observed in the closed supplementary pension fund market, given that CSPF managers have an interest in increasing their corporate longevity by managing the earnings of DB and VC plans. To accomplish this, the manipulation of the assumptions utilized in actuarial evaluations would be one of the paths to improve the earnings and solvency of these plans (Asthana, 1999; Kisser et al., 2017).

In addition, specificities related to closed supplementary pension funds, mainly in terms of DB and VC pension plans, have generated a strong asymmetry of information between CSPF and sponsor managers (agents), who are familiar with the assumptions that have a significant impact on mathematical provisions (actuarial liabilities); and the sponsor capital owners, participants, and beneficiaries (principals), who in general know little about this subject (Mello, 2020).

This asymmetry of information which is favorable to managers, offers opportunities in terms of the assumptions adopted in DB and VC plans, which can be used to please sponsors, participants, beneficiaries, or a regulatory agent, to the extent that mathematical provisions can be reduced in terms of the coverage's total assets, improving the plan's solvency, which would maximize career possibilities, power and remuneration of the agents (Teixeira et al., 2023).

2.2. Choices Made in Terms of the Assumptions Utilized in Actuarial Evaluations

The literature argues that the assumptions adopted in actuarial evaluations can be influenced by the financial health of pension plan sponsor firms (Asthana, 1999; Rauh, 2006); to meet given financial or regulatory plan solvency standards (Billings et al., 2016; Kisser et al., 2017; Teixeira et al., 2023; Westerduin et al., 2012); or to satisfy the pretensions of CSPF (Teixeira et al., 2022) and sponsor (Bergstresser et al., 2006) managers.

In terms of the financial health of the sponsor firm, the choice of assumptions may be motivated by visibility costs. In a summarized manner, the sponsor company guides the members nominated by the Executive Board or the Administrative Board of the CSPF, seeking to influence the assumption choices of the sponsored plans, in order to increase or decrease the volume of pension contributions (flow effect) depending on the company's economic and financial capacity (Asthana, 1999; Glaum et al., 2018).

For example, companies taxed on real profits that have good financial health have incentives to make assumption choices that increase mathematical provisions and the levels of contributions to the pension plans. This type of movement allows the sponsors to maximize their fiscal benefits, due to the deductibility of the pension expenses which make up the base for calculating their corporate tax (IRPJ) (Asthana, 1999) and Social Contribution on Net Profits (CSLL) (Teixeira, 2023). The attraction and retention of, and incentives for talented employees are other benefits derived from these choices (Azambuja, 2021).

On the other hand, companies taxed on net profits that have financial difficulties have motives to make assumption choices that reduce their mathematical provisions and the levels of contributions for their post-employment benefit plans (Rauh, 2006). These choices signal to investors and creditors that the company is seeking financial discipline by decreasing their expenses on their pension plans (Kisser et al., 2017).

In terms of meeting regulatory standards, it is argued that some CSPFs have incentives to manipulate assumption choices to meet certain parameters tied to the coverage index (solvency) of their plans, which is given by the quotient of the total assets of the coverage over the mathematical provisions (stock effect) (Billings et al., 2016; Kisser et al., 2017; Westerduin et al., 2012). For this type of motivation, the CSPF will seek to respect the solvency limits imposed by the regulatory body, avoiding deficits (Teixeira et al., 2023), penalties and interventions (Kisser et al., 2017).

Meanwhile, the assumptions motivated by relations that govern manager contracts in sponsors and CSPFs can be explained by the possibilities that these administrators manage to maximize their career chances, power, and remuneration, as proposed by Bergstresser et al. (2006) and Teixeira et al. (2022).

In this scenario, managers would seek to please sponsors, participants, and beneficiaries in financial difficulties, with assumption choices that reduce the mathematical provisions and level of contributions in the present, so that any adjustments would be relegated to the future (intertemporal choice). On the other hand, if the intention is to attract sponsors, participants, and beneficiaries in a comfortable financial situation, the assumption choices would be oriented by increasing the

mathematical provisions and the level of plan contributions (Teixeira, 2023).

2.3. Research Hypotheses

Since the objective of this study is to investigate whether Brazilian DB and VC plans present indications of discretion in the choice of assumptions utilized in actuarial evaluations, we have developed four research hypotheses. Research hypothesis **H1** is based on Teixeira (2023), which argues that the definition of a given dependent assumption can be influenced by other independent assumptions to eliminate or smooth the effect of the mathematical provisions on plans.

> **H1:** Solvent DB and VC plans compensate the use of some assumptions which increase mathematical provisions with other assumptions that reduce these same provisions.

When DB and VC plans are solvent, the eventual adoption of assumptions that increase the mathematical provisions of plans can have a negative impact on their solvency. In this manner, managers' compensatory use of some assumptions that reduce these provisions can mitigate or even discard the possibility that solvent plans will become insolvent (Asthana, 1999; Teixeira, 2023).

Research hypothesis **H2** seeks to analyze whether certain characteristics of DB and VC plans interfere in the choices of their assumptions. For example: the volume of funds coming from participants and sponsors; solvency; the plan's maturity; and the type of sponsor are attributes that can influence assumption choices (Billings et al., 2016; Kisser et al., 2017).

> **H2:** There is evidence that certain characteristics of DB and VC plans interfere with the choices of these assumptions.

Meanwhile, research hypothesis **H3** seeks to evaluate whether certain attributes of the companies that sponsor DB and VC plans can explain the choices of the assumptions made for these plans (Asthana, 1999; Billings et al., 2016).

> **H3:** There are indications that the attributes of companies that sponsor DB and VC plans affect the choices of the assumptions for these plans.

As a consequence, we examine whether companies with greater levels of cash, return on assets, and taxes to pay, as well as lower levels of indebtedness, are associated with assumption choices that have the potential to elevate mathematical provisions and the volume of pension contributions for plans. On the other hand, the opposite result of these measures would be related to the selection of assumptions that result in lower mathematical provisions and pension contributions for these same plans (Asthana, 1999; Billings et al., 2016; Glaum et al., 2018; Kisser et al., 2017).

Finally, research hypothesis **H4** deals with the influence of the economic environment on the adoption of assumptions in the actuarial evaluations of DB and VC plans. In Brazil, due to a history of high interest rates, supplementary pension plans always invest most of their resources in fixed income, mainly federal public bonds, achieving good returns associated with low risk (Associação Brasileira das Entidades Fechadas de Previdência Complementar [ABRAPP], 2021). In this manner, it is expected that increases in the Special System for Settlement and Custody (*Sistema Especial de Liquidação e de Custódia* – SELIC) rate would be associated with the selection of assumptions which diminish the mathematical provisions of the plans.

> **H4:** Increases in the SELIC rate are associated with assumption choices which reduce the mathematical provisions of DB and VC plans.

This signifies that elevated SELIC rates permit DB and VC plans to opt for more ambitious actuarial targets, given that the obtained return would be sufficient to provide reductions in the mathematical provisions and the volume of pension contributions, generating benefits for sponsors, participants, and beneficiaries in financial difficulties. In the same sense, reductions in the SELIC rate will lead to contrary results.

3. METHODOLOGY

The research hypotheses **H1**, **H2**, **H3** and **H4** are being investigated exclusively for DB and VC plans sponsored by companies that are listed on the Brazilian [B]^3 stock exchange. The idea is to apply to the Brazilian context an adaptation of the works of Asthana (1999), Billings et al. (2016), and Kisser et al. (2017). However, unlike these studies, the focus of this article will be on the regulatory environment of CSPFs, which follow the norms of the

CNPC and PREVIC, and not the environment of sponsor firms, which register their pension liabilities in accordance with CPC 33 (R1) – Employee Benefits, a norm correlated with International Accounting Standards (IAS) 19 – *Employee Benefits* (Resolução da Comissão de Valores Mobiliários n. 110 [Resolução CVM n. 110], 2022).

The data for this study was obtained from five databases, all referring to the annual period 2011-2020 (4th quarter). The first four databases were collected from the PREVIC website, and the last database for the sponsor firms was extracted from the Economatica system.

After cross-referencing the variables of interest present in the five databases, we obtained an initial sample of 1,052 DB plans, which are sponsored by companies listed on the Brazilian stock market. Nonetheless, it was necessary to exclude 303 observations that presented missing values for some of the variables of interest. Also excluded were 11 observations that could not be transformed and 129 observations to which a lag was applied to a portion of the explanatory variables, which yielded a final sample of 609 observations that could be utilized. Table 1 summarizes the construction of the final sample.

Meanwhile, for the VC plans, 1,048 observations were collected initially. However, it was necessary to exclude 105 observations of "pure DC" plans, that is, those that do not have actuarial risks, leaving VC plans and plans listed as DC, but which are VC in essence (or convertible to VC). In addition, we excluded 278 observations with missing data, 40 observations that could not be transformed, and 118 observations referring to variables that were lagged. The initial sample, the exclusions, and the final sample for VC plans can be observed in Table 2.

With the samples defined, three equations were tested using econometric models. The equations with the continuous dependent variable real interest rate (IR) were estimated through panel data models, following the procedures of least ordinary squares (OLS or pooled), random effects (RE), and fixed effects (FE).

The equations with dependent variables benefit capacity factor (BF) and the overall mortality table (MT) had to be categorized, and for this reason were estimated using nominal multinomial logit models.

Equations 1, 2 and 3 show all of the variables used in the models for the DB plans as well as the VC plans.

$$TIR_{i,t} = \alpha_i + \beta_1 SPI_{i,t} + \beta_2 SBF_{i,t} + \beta_3 SMT_{i,t} + \beta_4 SE_{i,t} + \beta_5 FE_{i,t} + \beta_6 RTA_{i,t} + \beta_7 MAT_{i,t} + \beta_8 VI_{i,t} + \beta_9 Exec_{i,t} + \beta_{10} DRS_{i,t} + \beta_{11} DC_{i,t} + \beta_{12} CH_{i,t} + \beta_{13} DTA_{i,t} + \beta_{14} ITP_{i,t} + \beta_{15} PTA_{i,t} + \beta_{16} SPO_{i,t} + \beta_{17} FPO_{i,t} + \beta_{18} SELIC_{i,t} + e_{i,t} \quad (1)$$

$$BFC_{i,t} = \alpha_i + \beta_1 SIR_{i,t} + \beta_2 SMT_{i,t} + \beta_3 SE_{i,t} + \beta_4 FE_{i,t} + \beta_5 RTA_{i,t} + \beta_6 MAT_{i,t} + \beta_7 VI_{i,t} + \beta_8 Exec_{i,t} + \beta_9 DRS_{i,t} + \beta_{10} DC_{i,t} + \beta_{11} CH_{i,t} + \beta_{12} DTA_{i,t} + \beta_{13} ITP_{i,t} + \beta_{14} PTA_{i,t} + \beta_{15} SPO_{i,t} + \beta_{16} FPO_{i,t} + \beta_{17} SELIC_{i,t} + e_{i,t} \quad (2)$$

$$MTC_{i,t} = \alpha_i + \beta_1 SIR_{i,t} + \beta_2 SPI_{i,t} + \beta_3 SBF_{i,t} + \beta_4 SE_{i,t} + \beta_5 FE_{i,t} + \beta_6 RTA_{i,t} + \beta_7 MAT_{i,t} + \beta_8 VI_{i,t} + \beta_9 Exec_{i,t} + \beta_{10} DRS_{i,t} + \beta_{11} DC_{i,t} + \beta_{12} CH_{i,t} + \beta_{13} DTA_{i,t} + \beta_{14} ITP_{i,t} + \beta_{15} PTA_{i,t} + \beta_{16} SPO_{i,t} + \beta_{17} FPO_{i,t} + \beta_{18} SELIC_{i,t} + e_{i,t} \quad (3)$$

Table 1
Selected sample for DB plans of [B]³ companies

Sample/year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Initial sample	105	101	103	104	105	108	108	108	106	104	1,052
(-) Missing data	(33)	(24)	(22)	(22)	(25)	(33)	(33)	(44)	(36)	(31)	(303)
(-) Not transformed	–	–	–	–	(1)	–	(10)	–	–	–	(11)
(-) Lagged	(72)	(11)	(7)	(2)	(1)	(4)	(3)	(14)	(8)	(7)	(129)
Final sample	**–**	**66**	**74**	**80**	**78**	**71**	**62**	**50**	**62**	**66**	**609**

Source: *Prepared by the authors.*

Table 2
Selected sample for VC plans of [B]³ companies

Sample/year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Initial sample	93	92	98	98	98	94	95	91	150	139	1,048
(-) Pure DC plans	–	–	–	–	–	–	–	–	(58)	(47)	(105)
(-) Missing data	(35)	(37)	(28)	(28)	(27)	(24)	(20)	(27)	(27)	(25)	(278)
(-) Not transformed	(2)	–	(6)	(3)	(5)	–	(11)	(3)	(2)	(8)	(40)
(-) Lagged	(56)	(4)	(15)	(5)	(4)	(8)	(7)	(9)	(8)	(2)	(118)
Final sample	**–**	**51**	**49**	**62**	**62**	**62**	**57**	**52**	**55**	**57**	**507**

Source: *Prepared by the authors.*

where the variable *TIR* refers to the dependent variable *IR* after passing through Box-Cox transformations in the DB (*lambda* = 2) and VC (*lambda* = 0) plans, to mitigate the non-normality of their distribution (Azevedo et al., 2016). In turn the dependent variable BFC has to do with the segregation of the BF variable in 3 categories (low, medium, and high), with MTC also portraying the separation of MT into 3 categories (lesser longevity, AT-2000 and greater longevity).

For BFC, we placed all the plans that had BF values below 0.98 in the "low" category. The "medium" category was composed of plans with BF greater than or equal to 0.98 and less than 0.99, and the "high" category contained all plans greater than or equal to 0.99.

For MTC, "lesser longevity" included the mortality tables with life expectancy less than table AT-2000; the "AT-2000" category was formed only by tables with this denomination; and the "greater longevity" category included only tables with life expectancies greater than table AT-2000.

In terms of the independent variables, they were divided into four groups. The first group refers to the *dummy* (*proxy*) variables which were created to identify the influence of a group of assumptions used in the actuarial evaluations on another given **H1** assumption. This was done because alterations in some assumptions can be compensated by modifications in another assumption (Asthana, 1999; Teixeira, 2023).

The variables that were created for this first group are: a dummy variable for plans that are simultaneously solvent and have real interest rates below the sample average (SIR); a dummy variable for plans that are simultaneously solvent and adopt indexers (or annual adjustment indices) above the sample average (SPI); a dummy variable for plans that are simultaneously solvent and use benefit capacity factors which are above the sample average (SBF); and a dummy variable for plans that are simultaneously solvent and adopt mortality tables with life expectancies equal to or superior to table AT-2000 in the sample (SMT).

Thus, solvent DB or VC plans that adopt better-behaved real interest rates, indexers that increase more intensely, larger capacity factors, and mortality tables with a life expectancy equal to or greater than table AT-2000, could be counterbalancing the selection of assumptions that increase mathematical provisions with other assumptions that reduce these same provisions so that the plans remain closer to equilibrium (Asthana, 1999; Teixeira, 2023).

The second group of variables seeks to evaluate whether certain characteristics of DB and VC plans interfere with the choices of their **H2** assumptions. The variables utilized in the second group to test **H2** were: plan solvency (coverage index) or stock effect (SE); the flow of pension contributions over total assets or the flow effect (FE); the annual plan return (surplus, equilibrium, or deficit) over total assets (RTA); a proxy for the maturity of the plan (MAT), given by the quotient of the conceded benefits

over the sum of benefits already conceded and those to be conceded in the future (Teixeira & Rodrigues, 2021); participation of the investments in variable income over total assets (VI); a dummy variable for plans which contribute funds above the sample average to remunerate the Executive Board of the CSPF (Exec); a dummy variable for plans located in the Federal District, the State of Rio de Janeiro or the State of São Paulo (DRS); and a dummy variable for plans with the DC nomenclature which can be converted to VC (DC), given that this variable was used only for the VC plan models. All of the variables in the second group were lagged for one period, except for DRS and DC.

Meanwhile, the variables of the third group seek to verify whether certain attributes of the sponsor firms listed on the [B]³ influence in some way the selection of assumptions for **H3** BD and VC plans (Asthana 1999; Billings et al. 2016; Kisser et al., 2017). If this is true, it cannot be denied that the managers of sponsor companies act in some way to interfere with the earnings of the pension funds in the CSPF context (Teixeira, 2023).

Thus, we utilized the variables for sponsor firms listed on the [B]³ stock exchange: cash on hand over total assets (CH); debt over total assets (DTA); a dummy variable for the existence of an income tax provision (ITP); profitability or net profits over total assets (PTA); a dummy variable for plans maintained by state publicly owned companies that are listed on the [B]³ (SPO); and a dummy variable for plans maintained by federal publicly owned companies that are listed on the [B]³ (FPO). All of these variables were lagged for one period, except for SPO and FPO.

An important point refers to the economic rationale behind the use of several lagged explanatory variables. Since the CSPFs choose the assumptions that will be in place in year *t* during year *t-1*, it is expected that the performance of some of the independent variables in year *t-1* can be influenced by the selection of the assumptions that will be in place during year *t*.

The fourth and last group deals with the influence of the economic environment on the assumption choices for DB and VC plans. Historically, elevated interest rates in Brazil have allowed supplementary pension plans to obtain good returns with low risk (ABRAPP, 2021). Thus, it is expected that increments in the SELIC allow plans to opt for assumption choices that generate smaller pension obligations, with the opposite also being true (**H4**).

In this sense, it should be emphasized that the SELIC acts fundamentally as a control variable in the models, given that an improvement in the return on bonds associated with this rate allows CSPF managers to rebalance their DB and VC plan portfolios (Silva et al., 2020). Thus, **H4** seeks to confirm empirically whether increments in the SELIC rate favor the selection of assumptions that reduce mathematical provisions.

4. RESULTS

4.1. Descriptive Statistics of DB and VC Plans

Initially, we elaborated the descriptive statistics of the quantitative variables contemplated in the DB plan regressions. Table 3 summarizes the results of these statistics.

The real interest rates adopted by DB plans over the investigated period varied from 3.50% to 10.73%, with an average of 5.07%. In turn, the plan indexer presented a minimum of 0.29% and a maximum of 23.08%, with an average of 6.24%. Meanwhile, in terms of the capacity factor, it may be observed that its value was in the interval from 0.9671 to 1.0000, with an average of 0.9803.

Concerning the same table, it is possible to highlight several statistics of the other variables, such as: a) the average SELIC rate, which was 9.68%; b) the average cash on hand in sponsor firms, which represented roughly 0.05% of their total assets; c) the average indebtedness of the sponsors, was on the order of 75.5% of their assets; d) the average net profits of the sponsors was equivalent to 2.06% of their assets; e) the coverage index of the plans, which indicated average solvency of 106% for DB plans; f) the annual average volume of plan contributions, which were equivalent to 5% of their assets; g) the median annual earnings, which indicated a surplus of 2% over total assets; h) the maturity of DB plans, which averaged 82% of the already conceded benefits; and i) the average investment in variable income, which was only 8% of the total assets of these plans.

In terms of the qualitative variables of the DB plans, the number of observations of the dependent variables capacity factor and overall mortality table were segregated into 3 categories. For the capacity factor, 58 observations were classified in the "high" category (the option that increases mathematical provisions); 377 observations in the "medium" (base category); and 174 observations in the "low" category (the option that reduces mathematical provisions).

Table 3
Descriptive statistics for quantitative variables for DB plans for 609 observations

Quantitative variables	Reference	Unit	Minimum	Avg.	Median	Maximum	Std. Dev.
Real interest rate (IR)	CSPF	%	3.50	5.07	5.00	10.73	0.75
Plan indexer (PI)	CSPF	%	0.29	6.24	5.56	23.08	3.30
Capacity factor (BF)	CSPF	Index	0.9671	0.9803	0.9800	1.0000	0.01
Transformed real interest rate (TIR)	CSPF	n^2	12.25	26.25	25.00	115.13	9.02
SELIC	BACEN	%	4.50	9.68	10.00	14.25	3.18
Cash on hand over total assets (CH)	Sponsor	%	0.00	0.05	0.03	0.71	0.07
Debt over total assets (DTA)	Sponsor	%	12.28	75.50	68.05	1.267.46	89.22
Profitability over total assets (PTA)	Sponsor	%	-160.20	2.06	3.10	37.62	11.59
Coverage index (SE)	CSPF	%	62.00	106.00	105.00	175.00	15.00
Contributions over total assets (FE)	CSPF	%	0.00	5.00	1.00	42.00	32.00
Return over total assets (RTA)	CSPF	%	-55.00	85.00	2.00	6.108.00	572.00
Maturity of the plan (MAT)	CSPF	%	14.00	82.00	90.00	100.00	19.00
Percentage of variable income (VI)	CSPF	%	0.00	8.00	7.00	39.00	8.00

Note: *The "n" unit refers to the value that went through a Box-Cox transformation and its power to the value of lambda. CSPF = Brazilian closed supplementary pension funds; BACEN = Brazilian Central Bank.*
Source: *Elaborated by the authors.*

Concerning the dependent variable overall mortality table, the "lesser longevity tables" (base category) contemplated 90 observations with lower life expectancies than the AT-2000 table; the "AT-2000 tables" consisted of 470 observations of the reference denomination; and the "greater longevity tables" consisted of 49 observations with life expectancies greater than the AT-2000 table.

In addition to this, the other qualitative variables provided the number of DB plan observations for those: a) located in the Federal District, Rio de Janeiro or São Paulo (382 plans) in comparison to those located in other Brazilian states (base category with 222 plans); b) which contribute more resources than average to remunerate the Executive Board of the CSPF (194 plans) *versus* those that contributed less than average (base category with 415 plans); c) which are state publicly owned companies (106 plans), federal publicly owned companies (50 plans) and private companies (base category with 453 plans); and d) which are sponsor companies with an income tax provision (537 plans) or not (base category with 72 plans).

In terms of the dummies (proxies) referring to the assumptions adopted in actuarial evaluations, 260 observations of the DB plans were solvent with lower than average real interest rates (SIR); 198 observations were solvent and used higher than average indices (SPI); 88 observations revealed solvency and higher than average capacity factors (SBF); and 342 observations demonstrated solvency and the use of mortality tables with life expectancies greater than or equal to the AT-2000 (STM).

Meanwhile, the descriptive statistics for the quantitative variables that were used for the VC plan regressions are displayed in Table 4. These statistics provide the minimum, average, median, maximum, and standard deviation for each of the variables, including the original and transformed dependent variables for the period 2011-2020.

First, we may observe that the real interest rates adopted by VC plans over the duration of the investigated period varied from 1.94% to 6.50%, with an average of 4.92%. The plan indexer, meanwhile, went from a minimum of 0.43% to a maximum of 23,08%, with an average of 6.06%. In terms of the capacity factor, the values were between 0.9671 and 1.0000, as occurred with the DB plans, with an average of 0.9822.

We can also highlight several statistics of other variables such as: a) the average SELIC rate which was 9.68%; b) the average of cash on hand among VC plan sponsors represented 0.06% of their total assets; c) the average indebtedness of the sponsors was approximately 78.48% of their total assets; d) the average net profits of the sponsors

Table 4
Descriptive statistics for quantitative variables for VC plans for 507 observations

Quantitative variables	Reference	Unit	Minimum	Avg.	Median	Maximum	Standard Deviation
Real interest rates (IR)	CSPF	%	1.94	4.92	5.00	6.50	0.58
Plan indexer (PI)	CSPF	%	0.43	6.06	5.56	23.08	3.08
Capacity factor (BF)	CSPF	Index	0.9671	0.9822	0.9800	1.0000	0.01
Transformed real interest rate (TIR)	CSPF	n^0	0.66	1.59	1.61	1.87	0.12
SELIC	BACEN	%	4.50	9.68	10.00	14.25	3.25
Cash on hand over total assets (CH)	Sponsor	%	0.00	0.06	0.04	0.71	0.07
Debt over total assets (DTA)	Sponsor	%	19.85	78.48	75.03	620.59	49.50
Net profits over total assets (PTA)	Sponsor	%	-173.49	2.05	2.58	67.99	12.43
Coverage index (SE)	CSPF	%	48.00	103.00	101.00	176.00	1.00
Contributions over total assets (FE)	CSPF	%	0.00	6.00	4.00	102.00	9.00
Return over total assets (RTA)	CSPF	%	-76.00	1.00	1.00	33.00	8.00
Maturity of the plan (MAT)	CSPF	%	0.00	42.00	41.00	96.00	26.00
Percentage in variable income (VI)	CSPF	%	0.00	9.00	9.00	3.00	7.00

Note: *The unit "n" refers to the value that went through a Box-Cox transformation and its power to the value of lambda. CSPF = Brazilian closed supplementary pension funds; BACEN = Brazilian Central Bank.*
Source: *Elaborated by the authors.*

was 2.05% of their total assets; e) the coverage index or stock effect had a value of 103%; f) the average volume of annual contributions in their plans was equivalent to 6% of their total assets; g) the average and median annual earnings indicated a surplus of 1% in both measurements; h) the maturity of the VC plans was on average 42% of their already conceded benefits; and i) the percentage of investments in variable income represented an average (median) of 9% of their plans' total assets.

In relation to the qualitative variables, they provided the number of observations of the dependent variables' benefit capacity factor and the overall mortality tables, each divided into 3 categories. For the capacity factor, in the first category "high" we obtained a total of 89 observations. In the second category "medium" (the base category) we had 314 observations. The third category "low", meanwhile had 104 observations.

In the overall mortality tables, the first "lesser longevity" category (the base category) contained 36 observations. The second "AT-2000" category was composed of 417 observations of this reference mortality table. Finally, the "greater longevity" category consisted of 54 observations.

In addition, the other qualitative variables provided the number of observations of VC plans with the following characteristics: a) those located in the Federal District, Rio de Janeiro, or São Paulo (321 plans) *versus* the plans located in other Brazilian states (the base category with 186 plans); b) DC plans convertible to VC plans (54 plans) *versus* original VC plans (base category 453 plans); c) plans that had above average contributions to the remuneration of the CSPF Executive Board (176 plans) *versus* those with below average contributions (the base category with 331 plans); d) plans maintained by federal publicly owned companies (49 plans), state publicly owned companies (94 plans) and private companies (base category with 364 plans); and f) plans in which the sponsor firms had income tax provisions (440 plans) or not (the base category with 67 plans).

In terms of the *dummy* variables for the assumptions used in the actuarial evaluations, it may be observed that 192 observations of VC plans were solvent and had below average real interest rates; 184 observations contemplated solvent VC plans which used above average indexers; 316 observations revealed solvency and above average capacity factors; and 368 observations represented solvent VC plans which used mortality tables with life expectancies greater than or equal to the AT-2000.

4.2. Evaluation of the Models for the DB Plans

First, it should be emphasized that even with the Box-Cox transformation (*lambda* = 2) in the dependent variable real interest rate (TIR), the Equation 1 model presented non-normality in the residuals. However, after the exclusion of 18 observations relative to 5 DB plans, the null hypothesis of normality of the residuals could not be rejected at a 5% level of significance by the Jarque-Bera test.

In terms of Equations 2 and 3, which deal with the determinants of the benefit capacity factor (BFC) and the overall mortality table (MTC), respectively, we realized estimations using nominal multinomial logit models. Table 5 presents the results of the estimated models for the DB plans.

Of the variables in the first group, the solvent DB plans with below average real interest rates (SIR) were associated with choices of capacity factors (BFC) of the base category (medium), compared to the low category and mortality tables (MTC) in the AT-2000 and greater longevity categories, which portrays an alignment of assumptions to increase mathematical provisions (Asthana, 1999). In turn, solvent DB plans with above average indexers and capacity factors (SPI) and (SBF), respectively, managed to explain a greater preference for MTC in the base category (lesser longevity), compared to the other categories, which indicates conduct to compensate assumptions (Asthana, 1999; Teixeira, 2023). Thus, we may observe that solvent DB plans with above average indexers or capacity factors prefer to balance the impacts on their mathematical provisions with the choices of mortality tables with a greater index of mortality. Thus, it is verified that **H1** cannot be rejected for the overall mortality table model.

In terms of the variables in the second group, increases in the stock effect (SE) are capable of simultaneously explaining the BFC in the low and high categories, which demonstrates an aversion to the base category. Meanwhile, increments in the flow effect (FE), profitability (PTA), and variable income (VI) affect the dependent assumptions TIR and BFC, and BFC and MTC, respectively, always related to reducing mathematical provisions, with the opposite occurring for DB plans which make above average contributions to the remuneration of the Executive Board of the CSPF (Exec), the TIR and MTC assumptions, and those located in the Federal District, Rio de Janeiro, and São Paulo (DRS) for the BFC assumption. In relation to longer maturity (MAT), we see a negative influence on TIR (an increase in mathematical provisions) and a lesser preference for BFC of the high category, compared to the base category (reduction in mathematical provisions). Thus, these findings do not permit the rejection of **H2**.

For the third group of variables, significant coefficients were found, which are associated with greater indebtedness (DTA), profitability (PTA) and the sponsor being a publicly owned state (SPO) or federal company (FPO), always with the assumption choices that elevate mathematical provisions in DB plans. In the case of DTA, it was expected that more indebted sponsors would influence their DB plans to choose assumptions which reduce the related mathematical provisions, which would generate smaller impacts (visibility costs) for shareholders, creditors, suppliers, and other stakeholders (Asthana, 1999; Billings et al., 2016). In relation to PTA, the significant coefficients demonstrate that more profitable companies tend to cause their DB plans to divulge greater mathematical provisions, as has been observed in the international literature (Asthana, 1999; Billings et al., 2016; Glaum et al., 2018). Meanwhile, for publicly owned state (SPO) and federal companies (FPO) it was verified that their DB plans always opt for assumptions which increase mathematical provisions, which results in an increase in sponsor pension obligations and offers new evidence that corroborates the findings of Teixeira et al. (2023). Only increases in cash on hand (CH) presented ambiguous results in BFC in the low and medium categories (reduction of mathematical provisions) and MTC in the AT-2000 category (increase in mathematical provisions). In this sense, the findings do not make it possible to reject **H3**.

Finally, elevated levels of the coefficient of the only variable in the fourth group (SELIC), manage to explain increases in TIR (a reduction in mathematical provisions) and a greater preference for the low and high categories of BFC (ambiguous effect). In terms of TIR, it can be verified that when the returns of securities associated with the SELIC increase, CSPF managers may reallocate their investments by buying more of these securities, which permits an increase in the real interest rate and a consequent reduction in the mathematical provisions divulged to the sponsors and participants. In this manner, **H4** can be considered valid only for the real interest rate model.

4.3. Evaluation of the Models for the VC Plans

Equation 1 gives the results of the panel data model for real interest rate. Initially, this model presented non-normality in the residuals, even after the Box-Cox transformation was realized (*lambda* = 0). However, after the exclusion of 27 observations linked to 7 plans, the null

Table 5
Models selected for equations 1, 2 and 3 for DB plans

Independent variables	Interest rates (TTJ)	Capacity factor (CFB)[c]		Mortality tables (CTM)[c]	
	Fixed effects[a]	Low	High	AT-2000	Greater Longevity
Intercept	NA[b]	-2.2730	-9.0652***	-1.5142	4.9412
		(1.6561)	(1.9073)	(2.2243)	(3.5470)
SIR		-2.1991***	0.3380	3.3152***	2;8988***
		(0.3660)	(0.5099)	(0.6823)	(0.8516)
SPI	-0.1817			0.1791	-10.5729***
	(0.3648)			(0.3926)	(0.0014)
SBF	-1.0828			-2.0404***	-0.6909
	(0.6740)			(0.6223)	(0.9061)
SMT	-0.0992	0.1532	-0.4722		
	(0.7210)	(0.3097)	(0.5285)		
SE	-0.5757	2,5904**	6.4717***	1.8168	-3.0939
	(2.1510)	(1,2334)	(1.5049)	(1.8350)	(2.7180)
FE	0.2386*	0,0560	-0.2263	-2,9877	5.9270
	(0.1166)	(3,0339)	(0.4914)	(3.8116)	(5.1166)
RTA	0.0751***	-0,2470	-0.0588**	0.4677	-0.9439
	(0.0173)	(0,4260)	(0.0277)	(0.5985)	(1.2187)
MAT	-11.3086***	-0,7372	-2.8827***	-0.2052	-0.9922
	(2.9261)	(0,6986)	(0.7622)	(0.8901)	(1.3349)
VI	-3.1125	6.7953***	1,5004	-7,9919***	-8.2824***
	(3.5345)	(1.6475)	(2,5010)	(18999)	(2.8935)
Exec	-2.5624**	-0.1794	-0,2323	1.0170***	0.6122
	(1.1498)	(0.2524)	(0.3800)	(0.3625)	(0.5461)
DRS	0.1521	-1.3397***	0.7533*	-0.1673	-0.7003
	(1.0987)	(0.2612)	(0.4446)	(0.3622)	(0.5193)
CH	-0.8777	2.6947*	-6.6761*	10.7741***	2.1731
	(2.2534)	(1.4755)	(3.7100)	(4.0080)	(6.0844)
DTA	-0.0024	-0.0284***	-0.0003	0.0087***	-0.0124
	(0.0019)	(0.0063)	(0.0035)	(0.0031)	(0.0120)
ITP	0.1114	0.0304	0.9903	0.0178	0.0955
	(0.5291)	(0.3504)	(0.6488)	(0.4241)	(0.6821)
PTA	-0.0453**	-0.0318*	-0.0231	0.0908***	0.0801*
	(0.0180)	(0.0193)	(0.0221)	(0.0250)	(0.0417)
SPO	-1.4788	-0.8146**	0.4859	1.3096***	0.6764
	(1.1131)	(0.3314)	(0.5628)	(0.4461)	(0.6363)
FPO	0.5376	-0.0037	-1.5564	0.2906	2.1953***
	(1.0786)	(0.4287)	(1.0826)	(0.6316)	(0.7659)
SELIC	0.4964***	0.2313***	0.1342**	0.0131	-0.0833
	(0.0562)	(0.0391)	(0.0545)	(0.0511)	(0.0693)
Number of observations	591	609	609		
R^2 adjust.	17.60%				
F Statistic	13.4704				
Prob. F	0.0000				
Pseudo R^2		41.28%		46.31%	
VIF max.	2.81	2.79		2.80	
AIC		883.76		648.53	
BIC		1,033.76		807.36	

**** Significant at 1%, ** significant at 5% and * significant at 10%.*
Note: [a] *Autocorrelation and heteroskedasticity corrected by the Huber-White robust standard error procedure.* [b] *Not applicable for the fixed effect estimator within.* [c] *The significance of the coefficients was evaluated by the Wald test. In addition, the Hosmer-Lemeshow and Hausman-McFadden Likelihood Ratio tests were favorable for the CFB and CTM models.*
Source: *Elaborated by the authors.*

hypothesis of the normality of the residuals could not be rejected at a 5% level of significance by the Jarque-Bera test.

For equations 2 and 3, meanwhile, which deal with the determinants of the benefit capacity factor (BFC) and the overall mortality table (MTC), respectively, estimates with nominal multinomial logit models were performed. All of the results are displayed in Table 6.

Concerning the variables in the first group, it was verified that when VC plans are solvent and opt for below average real interest rates (SIR), these plans prefer capacity factors (BFC) in the medium category, compared to the high category (reduction in mathematical provisions), and mortality tables (MTC) of the greater longevity category, as opposed to the lesser longevity category (increase in mathematical provisions). In turn, when VC plans are solvent and adopt above average indexers (SPI), these plans tend to increase their real interest rates (TIR) and choose mortality tables (MTC) of the lesser longevity category, compared to the greater longevity category, which would amount to a movement to reduce mathematical provisions. Thus, it may be concluded that it is not possible to reject **H1** for the 3 evaluated models, because there is evidence that the dependent assumptions are partially affected by several independent assumptions which reduce mathematical provisions (Asthana, 1999; Teixeira, 2023).

Concerning the variables in the second group, it can be ascertained that increases of stock in the plan funds (SE) are responsible for reductions in the real interest rate (TIR) (increase in mathematical provisions), for capacity factors (BFC) of the medium category, compared to the high and low categories and mortality tables (MTC) of the lesser longevity category, as opposed to the other categories (reduction in mathematical provisions). Meanwhile, increases in plans' flow of resources (FE); in investments in variable income (VI); the VC plan contributing to above average funding for remuneration of the Executive Board of the CSPF (Exec); and the DC plan which has a VC essence, brought the following results: a) FE explaining elevations in TIR; b) VI explaining elevations in TIR and the choice of BFC in the low category, compared to the base category; c) Exec influencing the choice of BFC in the low and medium categories; and d) DC preferring BFC in the low category and MTC of lesser longevity. In other words, the coefficients of these 4 variables represent options that reduce the mathematical provisions divulged to the plan stakeholders.

In the case of increasing returns over assets (PTA), we observe increments in TIR and a preference for BFC of the low category (options that reduce the mathematical provisions) and choices of BFC in the high category and MTC in the greater longevity category (options which increase the mathematical provisions). For elevations in the maturity of the plans (MAT) it was possible to verify increases in TIR and choices of BFC in the low and medium categories (options which reduce the mathematical provisions). On the other hand, increases in (MAT) also were responsible for choices of MTC in the AT-2000 and greater longevity categories (options which increase the mathematical provisions). Finally, the VC plan being located in the Federal District, Rio de Janeiro or São Paulo (DRS) indicated a preference for BFC in the medium and high categories, which elevate the mathematical provisions. Therefore, there is strong evidence that **H2** should not be rejected.

Concerning the third group of variables, increases in the cash available in the sponsor (CH) explain decreases in TIR, with an increase in mathematical provisions, and choices of BFC in the low and medium categories and MTC in the less longevity category, representing reductions in these same provisions. When the sponsor has greater debt (DTA), the VC plans tend to opt for BFC in the low category that reports lower mathematical provisions, just as VC plans of more profitable sponsors (PTA) prefer to reduce their interest rates, which increases their mathematical provisions. These last two findings follow the proposals of Asthana (1999) and Kasaoka (2021). According to these authors, more indebted companies tend to release lower mathematical provisions for their plans, with the opposite occurring in more profitable firms. Meanwhile, state publicly owned companies (SPO) prefer BFC in the high category (increased mathematical provisions) and MTC in the lesser longevity category (reduction of mathematical provisions), while federal publicly owned companies (FPO) opt for BFC in the medium category as compared to the low category (increase in mathematical provisions) and MTC in the lesser longevity category (reduction of mathematical provisions). Thus, these results do not permit the rejection of **H3**.

Finally, for the fourth group, which only includes the macroeconomic variable (SELIC), it can be inferred that in general, increases in the economy's basic interest rate can explain higher real interest rates (TIR) in VC plans (reduction in mathematical provisions) and a preference for capacity factors in the low category (reduction of mathematical provisions) and the high category (increase in mathematical provisions) which signifies that **H4** cannot be rejected for the TIR model, as also occurred in DB plans.

Table 6
Models selected for equations 1, 2, and 3 for the VC plans

Independent variables	Interest rates (TTJ)	Capacity factor (CFB)		Mortality table (CTM)	
	Random effects	Low	High	AT-2000	Greater longevity
Intercept	1.6629***	22.5910***	23.6350***	2.1271*	85.0800***
	(0.1203)	(1,8524)	(1.9149)	(1.2041)	(2.2687)
SIR		-0.0001	-1.1712***	0.4580	1.6390**
		(0.3971)	(0.3973)	(0.4684)	(0.7144)
SPI	0.0145**			0.3242	-12.6840***
	(0.0007)			(0.4558)	(0.0008)
SBF	-0.0070			0.3328	0.4090
	(0.0119)			(0.4862)	(0.7117)
SMT	-0.0116	-0.0233	0.7234		
	(0.0185)	(0.3888)	(0.5089)		
SE	-0.2672**	-29.1200***	-29.8120***	-1.8783*	-83.8000***
	(0.1122)	(1.7939)	(1.5271)	(1.0738)	(2.2991)
FE	0.1752***	0.6530	2.5738	-1.3316	-0.5067
	(0.0533)	(3.4491)	(2.3788)	(1.7863)	(3.4484)
RTA	0.3232***	34.5710***	56.4650***	2.9721	96.2250***
	(0.0950)	(2.8831)	(2.2825)	(2.0373)	(3.5067)
MAT	0.1240***	1.7478**	-2.3941**	2.2000**	4.3585***
	(0.0392)	(0.7667)	(0.9863)	(1.0736)	(1.4506)
VI	0.4945***	9.5194***	1.4226	1.8607	-5.8004
	(0.0734)	(2.5118)	(2.7592)	(3.1608)	(4.4049)
Exec	-0.0031	1.2550***	-1.0547*	0.1809	-0.5397
	(0.0135)	(0.3660)	(0.5469)	(0.5039)	(0.6512)
DRS	-0.0034	-1.1211***	4.1178***	0.1587	-0.6915
	(0.0205)	(0.4242)	(0.9935)	(0.5631)	(0.7465)
DC	-0.0122	0.9648**	-0.3269	-1.7722***	-0.3536
	(0.0176)	(0.4235)	(0.7929)	(0.4878)	(0.7081)
CH	-0.2554***	6.9870***	-11.1729**	6.7599	-14.3290**
	(0.0601)	(2.1754)	(4.6282)	(4.2862)	(6.5193)
DTA	-0.0001	0.0075*	-0.0068	0.0095	0.0055
	(0.0001)	(0.0044)	(0.0120)	(0.0091)	(0.01092)
ITP	-0.0003	0.4172	1.0350	0.0021	-0.9586
	(0.0132)	(0.4492)	(0.6473)	(0.5879)	(0.7735)
PTA	-0.0005***	-0.0033	-0.0195	0.0256	0.0362
	(0.0002)	(0.0161)	(0.0285)	(0.0277)	(0.0340)
SPO	0.0431	0.0564	1.6896*	0.0783	-1.8832**
	(0.0274)	(0.5080)	(0.9229)	(0.6410)	(0.9304)
FPO	0.0131	-2.7844**	-0.1845	0.9109	-3.3835**
	(0.0359)	(1.1760)	(0.7391)	(0.9520)	(1.5100)
SELIC	0.0125***	0.2145***	0.1436***	-0.0199	-0.0252
	(0.0012)	(0.0488)	(0.0540)	(0.0687)	(0.0830)
Number of observations	480	507	507		
R^2 adjusted	77.11%				
χ^2	298.36				
Prob. χ^2	0.0000				
Pseudo R^2		61.27%		39.46%	
VIF max.	7.42	7.66		7.73	
AIC		643.34		509.89	
BIC		795.57		670.57	

**** Significant at 1%, ** significant at 5% and * significant at 10%.*
Note: [a] *Autocorrelation and heteroskedasticity corrected by the Huber-White robust standard error procedure.* [b] *The significance of the coefficients was evaluated by the Wald test. In addition, the statistics of the Hosmer-Lemeshow and Hausman-McFadden Likelihood Ratio tests were favorable for both models.*
Source: *Elaborated by the authors.*

5. FINAL CONSIDERATIONS

This study has investigated whether DB and VC plans in Brazilian CSPFs present evidence of discretion in the choices of the assumptions used in their actuarial evaluations. To accomplish this, we have utilized 4 groups of independent variables, with each group portraying a hypothesis in order to attempt to explain assumptions related to the real interest rate, the benefit capacity factor, and the overall mortality table.

In the DB models, the research hypothesis **H1** cannot be rejected for the overall mortality table assumption, while **H4** was not refuted for the real interest rate assumption. In turn, hypotheses **H2** and **H3** could not be disproved for all of the analyzed assumptions, that is, the real interest rate, the benefit capacity factor, and the overall mortality table.

Meanwhile, for the VC plans, it was not possible to reject the research hypotheses **H1**, **H2**, and **H3** for all of the evaluated assumptions, with the refuting of the **H4** hypothesis did not prove viable for the real interest rate assumption, as occurred in the DB plans.

Thus, based on the model results, we can make some general reflections. First of all, there is evidence of the compensatory use of different assumptions, with the objective being to smooth the impact on the mathematical provisions of these plans, but this appears to occur with greater intensity in VC plans than DB plans. This behavior can be explained by the managers' need to reduce their costs of visibility in terms of the plan sponsors, participants, and beneficiaries, with the intent to demonstrate their managerial competence (Asthana, 1999; Teixeira, 2023).

Second, in the DB and VC plan models, it was found that increments in the flow effect (FE) and the percentage of resources allocated in variable income (VI) always are associated with choices of assumptions which reduce the mathematical provisions. Thus, we have that plans which receive more resources from pension contributions and apply greater portions of these resources in more risky investments (stocks, mutual funds, multimarket funds, etc.) in search of higher returns prefer to divulge smaller pension obligations to their sponsors, participants, and beneficiaries. In other words, these results suggest that a larger monthly infusion of resources and the possibility of greater gains lead the upper administration of CSPFs to want to report a lower level of obligations for their pension plans (Teixeira, 2023).

Third, both DB as well as VC plans located in the Federal District, Rio de Janeiro or São Paulo influence the capacity factor by reporting greater mathematical provisions to their stakeholders, which to a certain extent is not in consonance with the study of Teixeira et al. (2023). These authors found that DB and VC plans located in the Federal District, Rio de Janeiro, or São Paulo preferred to report greater solvency compared to plans located in other Brazilian states.

Fourth, there is consistent evidence that when companies listed on the [B]³ increase their returns over their assets (PTA), these companies influence their DB and VC plans and choose assumptions that increase the obligations of these plans. In other words, it was verified that companies in better economic health tend to direct more resources to the pension plans in order to retain talent and diminish their expenses on corporate income taxes (IRPJ) and social contributions (CSLL), which is in line with the national and international literature (Asthana, 1999; Azambuja & Campani, 2021; Billings et. al. 2016; Kasaoka, 2021).

Fifth, in a general manner, publicly owned companies (state or federal) that are listed on the [B]³ tend to choose assumptions that increase the mathematical provisions of the DB plans, which generates a greater need for financial resources for these plans. These results are consistent with a study by Teixeira et al. (2023), which diagnosed that publicly owned companies exhibit less aggressive conduct in the management of their pension liabilities, compared to their private peers, presenting a lower level of solvency in their pension plans.

Sixth, it was ascertained that when VC plans have a DC nomenclature, these plans opt for assumptions with the capacity to reduce mathematical provisions. This may mean that CSPFs are managing the mathematical provisions of DC plans with a VC essence, to hide the actuarial risks from sponsors and lay participants in this subject, given that a plan denoted "DC" should not report a lack of financial resources (Teixeira et al., 2023).

Finally, we found that increases in the SELIC rate are important in explaining real interest rates for DB and VC plans, which result in a lower value of mathematical provisions reported to sponsors, participants, and beneficiaries. A plausible explanation for this movement is that, when public and private securities associated with the SELIC rate offer greater returns, there are incentives for the rebalancing of plan portfolios (Silva et al., 2020), which also justifies the adoption of more daring actuarial targets. After all, low risk and high returns are a powerful combination for the agents that need to achieve solvency for the DB and VC plans.

Thus, based on the results of the econometric models and their analyses, it is not possible to discard that the assumptions for DB and VC plans are subject to discretionary actions on the part of their managers to a greater or lesser extent. Hence, these findings provide elements for the National Council on Supplementary Pensions (CNPC) to revise or create more rigorous and uniform parameters, which limit the use of assumptions as instruments to deliberately alter the solvency of plans.

O'Brien (2020) corroborates this vision, by affirming that the solvency published by plans with defined benefits can be hidden by the discretion used in choosing their assumptions. This author further proposes that regulators require that the adopted assumptions be based on solid, objective, neutral, transparent, and viable principles, which is also emphasized by Azambuja and Campani (2022).

As an opportunity, we recommend that future studies investigate the subject of hierarchy in discretionary actions regarding the assumptions involved in pension fund liabilities in Brazil, as Billings et al. (2016) did in Great Britain. This issue is relevant, because the National Council on Supplementary Pensions (CNPC) and the National Superintendency for Supplementary Pensions (PREVIC) regulate discretion regarding assumptions asymmetrically, which generates various possibilities for alterations in the volume of pension obligations reported to sponsors, participants, and beneficiaries.

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