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Impacts of the regulatory model for market risk capital: application in a special savings company, an insurance company, and a pension fund

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ABSTRACT

In line with the regulation brought in by Solvency II, the Superintendence of Private Insurance (Susep) introduced the market risk capital requirement at the end of 2015, with 50% of the minimum capital for this type of risk being required by December 31st 2016 and 100% the following year. This regulatory model consists of calculating parametric value at risk with a 99% confidence level and a three month time horizon, using the net exposure of expected cash flows from assets and liabilities and a covariance matrix updated with market data up to July 2014. One limitation of this regulatory approach is that the updating of the covariance matrix depends on prior approval by the National Council of Private Insurance, which can limit the frequency the covariance matrix is updated and the model's adherence to the current market reality. As this matrix considers the period before the presidential election, the country's loss of investment grade status, and the impeachment process, which all contributed to an increase in market volatility, this paper analyses the impacts of applying the regulatory model, considering the market volatility updated to December 31st 2015, for a special savings company (*sociedade de capitalização*), an insurance company, and an pension fund. Furthermore, the paper discusses the practical implications of the new market risk requirement for managing the investments of the entities supervised by Susep, listing the various assumptions that can be used in the regulated entities' Asset and Liability Management decision models and possible trade-offs to be addressed in this process.

Keywords: regulatory capital, market risk capital, solvency, pension, open pension fund.

1. INTRODUCTION

Different stakeholders can have different views with regards to the optimal capital structure (proportion of own capital and third-party capital) for companies. Shareholders, aiming to maximize return and minimize risk, tend to prefer the minimum allocation of capital, while other stakeholders, such as funders, prefer the maximum capital possible, since in the event of possible misfortunes over the course of business, the possible loss can be mitigated by a company's own capital. Within this setting the following question arises: is the market capable of functioning adequately without the State's interference. This is a big question guiding the discussion between regulation and self-regulation, with the former predicting that government rules should restrict private activity in order to maintain market equilibrium, while the latter argues that the rules should be set by market participants themselves.

Due to the economic, financial, and social relevance of the financial and insurance market, the perspective that has stood out, although regulation and self-regulation are to some extent complementary, is the one that argues that it is the State's job to intervene in the market, by establishing standards, however minimum, to guarantee the stability of the system and correct possible distortions. The more complex the products and services involved, the greater the need for State regulation, in order to uphold commitments made to the most vulnerable (in other words consumers) and maintaining market equilibrium forms part of this.

Along these lines and given the increased complexity of financial services and scandals involving big corporations, the Basel II Accord emerged (and subsequently Basel III), introducing methodologies for calculating minimum levels required of capital that are more sensitive to risk, allowing a lower capital allocation for institutions that use risk management practices better. This tendency for the insurance market in European Union countries has resulted in Solvency II.

Following the global movement, in Brazil new solvency rules for the insurance market have been issued, initially establishing those for capital allocation to cover subscription, credit, and operational risks.

In December 2014, CNSP Resolution n. 317 was issued (Superintendence of Private Insurance [Susep], 2014) and subsequently consolidated by CNSP Resolution n. 321 (Susep, 2015) and altered by CNSP Resolution n. 343 (Susep, 2016). It introduced criteria for calculating risk capital based on market risk for insurers (INSs), pension funds (PFs), special saving companies (SSCs), and local reinsurers. The regulatory model consists of calculating parametric value at risk (VaR), considering 99% confidence for a three month time horizon. However, the covariance matrix established in the rule for calculating VaR was updated up to July 2014, prior to the presidential election, the country's loss of investment grade status, and the impeachment process, which all contributed to an increase in market volatility. Besides this limitation of this regulatory approach, in order to update the covariance matrix to best reflect the underlying reality, a new resolution needs to be approved by the National Council of Private Insurance (CNSP), limiting the frequency of updates and the adequacy of the covariance matrix to the current market reality. Along these lines, given the increase in market volatility, the following question arises: what is the impact of updating the covariance matrix in the VaR calculation for market risk capital purposes?

This article therefore seeks to analyze the results of applying the approach defined by CNSP Resolution n.321 (Susep, 2015), incorporating market volatility up to December 31st 2015, for market risk capital for an SSC, an INS, and an PF. Moreover, the paper will discuss the practical implications of the new market risk requirement for managing the investments of entities supervised by the Superintendence of Private Insurance (Susep).

The article is divided into five sections, including this introduction. The second section presents the literature review, the third presents the methodology used, and the fourth constitutes an analysis of the need to adjust regulatory capital for the case presented. Finally, the fifth section presents the conclusions.

2. THEORETICAL FRAMEWORK

2.1 Capital Requirement

Since the 1980s, financial institution and insurance company operations have evolved considerably, particularly with the regulations introduced by the Basel and Solvency accords. The regulations are structured based on the same three pillars:

- Pillar I — Quantitative Requirements: calculation of solvency capital requirements and minimum capital required based on a standard or an internal model.
- Pillar II — Supervisor review: general principles that govern the regulation of risk management and internal controls and process reviews.
- Pillar III — Market discipline: guidelines regarding the transparency and reporting of information related to solvency and financial situation.

These pillars seek to incentivize better practices for managing the risks to which INSs, reinsurers, SSCs, and PFs are exposed and can be found both in the recommendations from the International Association of Insurance Supervisors (IAIS, 2005) and in Solvency II of the European Union (Directive of the European Parliament and of the Council [EC], 2009) and in the Basel II accord (Basel Committee on Banking Supervision [BCBS], 2004) for banks.

In Brazil, Susep and CNSP have worked on developing the regulatory and supervisory framework based on the three pillars instituted in Solvency II.

In Pillar I, the regulation for additional capital for risk of insurer and reinsurer damage claims was introduced by CNSP resolutions n. 158 (Susep, 2006) and n. 188 (Susep, 2008), respectively. The criteria for establishing the capital for credit risk originated with CNSP Resolution n. 228 (Susep, 2010) and the capital for operational risk was regulated by CNSP Resolution n. 283 (Susep, 2013).

In 2013, in continuity of the polic•y for implanting supervision based on risk, Susep established a technical group to present the criteria and methodologies for measuring the regulatory risk capital requirement related to the market risk of supervised companies.

According to the presentation from the Susep technical group, carried out on April 26th 2013, the market under supervision accounted for R$ 549 billion in assets, with R$ 462 billion in financial assets distributed in the following way:

- R$ 424 billion for the insurance segment;
- R$ 1 billion for the PF segment;
- R$ 29 billion for the special savings company segment;
- R$ 8 billion for the local reinsurer segment.

The relevance of the numbers highlights the economic and social importance of these segments in Brazil and explains the regulatory body's concern with defining the basic metrics to be observed in order to maintain the solvency of the sector.

According to CNSP Resolution n. 317 (Susep, 2014), consolidated by CNSP Resolution n. 321 (Susep, 2015), INSs, PFs, SSCs, and local reinsurers will have to completely adjust to the new capital regulation for market risk by 2017, with the following capital requirement chronogram being established:

a. 0% of the capital for market risk by December 30th 2016;
b. 50% of the capital for market risk between December 31st 2016 and December 30th 2017; and
c. 100% of the capital for market risk by December 31st 2017

This shows that the subject of this study is contemporary and extremely relevant for the companies supervised by Susep.

Moreover, given the relevance of this regulation, CNSP Resolution n. 343 (Susep, 2016) altered the way of calculating adjusted net equity (ANE) to make it more sensitive to variations in the market value of assets and liabilities and suited to the introduction of the capital portion for market risk.

2.2 Asset and Liability Management

The use of the concept of market risk based on the net exposure between assets and their respective liabilities serves as a factor that incentivizes the use of asset and liability management (ALM) practices by the entities under Susep supervision.

The basic aim of an entity is to retain enough reserves to honor commitments to its participants or clients, however the uncertainty component with regards to what the assets and liability values will be, and consequently the mismatch between these, make the task of managing this process a challenge. Within this setting, ALM is a

key process for risk management, enabling decisions to be taken that are consistent with the behavior of an organization's assets and liabilities, and making it possible to monitor and control management variables, such as liquidity, solvency, and return, among others. With the new market risk capital requirement issued by Susep, this variable is added to the scope of the ALM process in the supervised entities.

The ALM models can be divided into two main categories: deterministic models and stochastic models. The first group includes the cash flow matching models, which seek a set of assets with a cash flow equal to that of the liabilities, and dedication, which seek assets with the closest cash flow possible to that of the liabilities (due to the difficulty of finding assets that make cash flow matching possible).

The dedication models gave rise to the immunization models (Ryan, 2014), whose core idea is to find an asset portfolio, at the lowest price possible, whose cash flow is greater or equal to that of liabilities.

The measures used for this purpose are normally dollar-duration and convexity; however these measures assume parallel shifts in interest rates, which is difficult to find in practice. More advanced measures, such as key rate duration vectors, have been proposed in the literature (Nawalkha, Soto, & Zhang, 2003); however a recent study (Carcano & Dall'O, 2011) found evidence that the use of more sophisticated models leads to a higher exposure to model errors, reducing the quality of the hedge created by these approaches.

In the second category, that of stochastic models, optimization models are used, considering the possible variations in cash flows and asset and liability values, which take on a stochastic behavior. The scope of this category ranges from the models that consider dynamic programming (Cairns, Blake, & Dowd, 2006) to models based on risk quantiles, such as VaR (Blake, Cairns, & Dowd, 2001).

2.3 Market Risk

Market risk has developed considerably since 1994, with JP Morgan bank publishing the RiskMetrics methodology (Morgan, 1996), in which the VaR metric came to be the reference for calculating market risk both in the academic field and in the financial market.

VaR is defined as the highest loss expected for a time horizon and a particular confidence interval. VaR can be calculated in different ways, according to the three methodologies first presented by Risk Metrics: Parametric (which assumes that financial returns have a known distribution), Historical Simulation (in which the quantile established by the VaR is sought in the historical distribution of the portfolio returns that are being analyzed), and Monte Carlo Simulation (which seeks to simulate the behavior of market prices).

Like the Brazilian Central Bank (BCB), which uses VaR as a metric for the market risk capital requirement for its regulated entities, in the insurance market Susep adopted VaR as a metric for calculating the capital requirement for market risk.

As established by CNSP Resolution n. 317 (Susep, 2014), the required capital for market risk will be the parametric VaR for three months, with 99% confidence.

The covariance matrix for calculating the parametric VaR is estimated using the exponentially weighted moving average (EWMA), based on the parameters of the term structure of interest rates (TSIR) published monthly by the authority itself, and used for the liability adequacy test (LAT) calculation, as well as the Bovespa Index, dollar, and Brazil Commodities Index (BCI) series of returns. The covariance matrix adopted in the current resolution refers to July 2014.

3. INTEREST PROBLEM AND METHODOLOGY

This paper aims to analyze the impacts of the new market risk capital requirement by evaluating the results for an SSC, an INS, and an PF, for December 2015.

As well as the direct impact of the capital requirement on these companies, the possible reflection on the need for market risk capital will also be analyzed, where data up to December 2015 update the covariance matrix used in calculating VaR, given that the current matrix uses data up to July 2014.

The covariance matrix will be updated in accordance with the methodology established by Susep, which consists of applying the EWMA method for the most recent data. The updating method is based on the standard EWMA formula,

$$\sigma_t^2 = \lambda\sigma_{t-1}^2 + (1-\lambda)r_{t-1}^2$$

in which σ is the variance, λ is the decay factor used to update the information, and *r* is the return of the series analyzed. For each item in the matrix, the covariance is estimated using the following correlation formula:

$$\rho_{a,b} = \frac{Cov(r_a, r_b)}{\sigma_a \sigma_b}$$

converted into:

$$Cov(a,b)_t = \rho\sigma_{a,t}\sigma_{b,t}$$

in which the estimates for volatility σ will be those obtained by the EWMA and the correlation ρ used will be the historical correlation of the series, considering the same period used by Susep to estimate the decay factors. The decay factors used will be the same published by Susep in the Market Risk Report — Calculation of Factors — GT. The factors are presented in Table 1:

Table 1 *Decay factors*

Series of returns	Decay factor
Fixed rate	0.92
IGP-M linked rate	0.85
IPCA linked rate	0.94
RR linked rate	0.92
Foreign exchange linked rate	0.73
IGP-M	0.97
IPCA	0.96
RR	0.97
Bovespa Index	0.96
Dolar	0.96
ICB	0.98

IGP-M: Brazilian General Market Price Index; IPCA: Brazilian Consumer Price Index; RR: reference rate.
Source: *Elaborated by the authors.*

It also bears mentioning that the methodology established in the calculation of the net exposures between assets and liabilities, which are mapped by maturity and risk factor in the VaR calculation, does not consider new business, but merely the risk already assumed until then by the supervised entities (it presupposes run-off companies).

Besides VaR, the analyses will also use marginal VaR, which measures how much the VaR would change for a monetary unit change in each exposure, and component VaR, which measures how much each exposure contributes to total VaR (Alexander, 2009; Gourieroux, Laurent, & Scaillet, 2000).

Despite the better alternative for reducing the VaR defined by the model, and consequently, the required capital being the decrease in the net exposure in the risk factors via ALM tools, these metrics serve as a parameter for evaluating the contributions from each factor to the total VaR.

4. RESULTS

The first stage in the analysis consists of allocating the financial flows of the assets and liabilities into the risk factors, or fixed maturities, in the net exposure calculation for each factor.

The net exposure data for the three companies are presented in Table 2 and are divided by the respective total financial assets, in order not to leave the numbers of the three companies apparent.

Table 2 *Net exposures by risk factor*

Maturity	Risk factor	SSC (%)	INS (%)	PF (%)
1	Dollar	0.000	0.000	0.000
21	Foreign exchange linked rate	0.000	0.000	0.000
63	Foreign exchange linked rate	0.000	0.000	0.000
126	Foreign exchange linked rate	0.000	0.000	0.000
252	Foreign exchange linked rate	0.000	0.000	0.000
378	Foreign exchange linked rate	0.000	0.000	0.000
504	Foreign exchange linked rate	0.000	0.000	0.000
630	Foreign exchange linked rate	0.000	0.000	0.000
756	Foreign exchange linked rate	0.000	0.000	0.000
1008	Foreign exchange linked rate	0.000	0.000	0.000
1260	Foreign exchange linked rate	0.000	0.000	0.000
2520	Foreign exchange linked rate	0.000	0.000	0.000
1	IGP-M	0.000	4.220	-7.266
63	IGP-M linked rate	0.000	0.409	-0.830
126	IGP-M linked rate	0.000	0.473	-0.997
252	IGP-M linked rate	0.000	0.567	-1.242
378	IGP-M linked rate	0.000	0.505	-1.340
504	IGP-M linked rate	0.000	0.616	-0.479
630	IGP-M linked rate	0.000	0.515	-0.269
756	IGP-M linked rate	0.000	0.451	0.316
1008	IGP-M linked rate	0.000	0.352	1.132
1260	IGP-M linked rate	0.000	0.734	3.067
2520	IGP-M linked rate	0.000	-0.048	3.440
3780	IGP-M linked rate	0.000	0.610	2.819
5040	IGP-M linked rate	0.000	-0.405	1.775
6300	IGP-M linked rate	0.000	-0.321	-0.008
7560	IGP-M linked rate	0.000	-0.161	-0.033
8820	IGP-M linked rate	0.000	-0.076	-0.030
10080	IGP-M linked rate	0.000	-0.036	-0.022
11340	IGP-M linked rate	0.000	-0.016	-0.014
12600	IGP-M linked rate	0.000	-0.011	-0.020
1	IPCA	44.614	8.075	-5.997
63	IPCA linked rate	1.876	0.813	0.068
126	IPCA linked rate	1.008	1.327	0.090
252	IPCA linked rate	2.339	1.610	0.134
378	IPCA linked rate	4.264	1.492	0.125
504	IPCA linked rate	2.380	1.038	0.147
630	IPCA linked rate	1.445	0.834	0.168
756	IPCA linked rate	3.315	1.076	0.220
1008	IPCA linked rate	4.075	0.945	0.290
1260	IPCA linked rate	7.756	0.681	0.699
2520	IPCA linked rate	6.874	-0.665	0.902
3780	IPCA linked rate	2.531	-0.884	0.701
5040	IPCA linked rate	1.926	-0.484	0.609
6300	IPCA linked rate	1.120	-0.204	0.470
7560	IPCA linked rate	1.432	-0.017	0.770
8820	IPCA linked rate	0.561	0.194	0.529
10080	IPCA linked rate	0.076	-0.004	0.076

Table 2 *Cont.*

Maturity	Risk factor	SSC (%)	INS (%)	PF (%)
11340	IPCA linked rate	0.000	-0.007	0.000
12600	IPCA linked rate	0.000	-0.006	0.000
1	RR	-53.272	-0.457	1.767
63	RR Linked rate	4.701	-0.009	-0.342
126	RR Linked rate	3.782	-0.018	-0.419
252	RR Linked rate	-0.369	-0.021	-0.426
378	RR Linked rate	-9.193	-0.026	-0.261
504	RR Linked rate	-8.713	-0.023	-0.107
630	RR Linked rate	-7.256	-0.018	-0.049
756	RR Linked rate	-9.852	-0.024	-0.032
1008	RR Linked rate	-11.622	-0.036	-0.021
1260	RR Linked rate	-14.333	-0.091	-0.025
2520	RR Linked rate	-2.473	-0.093	-0.037
3780	RR Linked rate	-0.005	-0.049	-0.023
5040	RR Linked rate	0.000	-0.024	-0.013
6300	RR Linked rate	0.000	-0.011	-0.007
7560	RR Linked rate	0.000	-0.005	-0.004
8820	RR Linked rate	0.000	-0.002	-0.002
10080	RR Linked rate	0.000	-0.001	-0.001
11340	RR Linked rate	0.000	0.000	0.000
12600	RR Linked rate	0.000	0.000	0.000
21	Fixed rate	0.525	-1.052	-0.007
63	Fixed rate	0.354	-1.070	0.000
126	Fixed rate	0.347	-0.634	0.007
252	Fixed rate	0.453	-0.249	0.174
378	Fixed rate	4.026	0.199	0.009
504	Fixed rate	3.527	0.025	0.098
630	Fixed rate	0.327	-0.139	0.008
756	Fixed rate	0.525	0.029	0.222
1008	Fixed rate	-0.026	-0.032	0.039
1260	Fixed rate	0.900	0.066	0.040
2520	Fixed rate	0.150	0.009	0.064
3780	Fixed rate	0.000	0.000	0.000
1	Stock	0.268	0.164	0.000
1	Commodities	0.000	0.000	0.000

SSC: special savings company; PF: pension fund; INS: insurer; IGP-M: Brazilian General Market Price Index; IPCA: Brazilian Consumer Price Index; RR: reference rate.

Source: *Elaborated by the authors.*

For the SSC, apparently the company's strategy is to manage the risk of exposure of liabilities indexed to the reference rate (RR) by allocating into assets indexed to the Brazilian Consumer Price Index (IPCA).

As for the INS, there is no clear standard, given that the positive net exposures are distributed into various categories of risk factors, as well as the negative net exposures.

With regards to the PF, it appears that in order to address the residual liabilities indexed to the RR and to the Brazilian General Market Price Index (IGP-M), the company allocates into assets indexed to the fixed rate and IPCA rates. It bears mentioning that Table 2 presents the net exposure of each one of the analyzed companies; that is, if the allocation into assets in a particular risk factor is greater than the exposure of obligations, it is not possible to identify that the company has liabilities exposed to that risk factor.

The next step was to calculate the capital requirement for the three companies, using the published methodology. The capital requirement results, measured in percentage of total financial assets, are presented in Table 3.

Table 3 *Capital requirement for market risk*

	SSC (%)	INS (%)	PF (%)
VaR	3.25	0.39	2.18

SSC: special savings company; PF: pension fund; INS: insurer; VaR: value at risk.
Source: *Elaborated by the authors.*

The VaR is only the starting point for a market risk management model, from which it is possible to evaluate the possible impacts on the current position of an entity's investments. Using marginal VaR and component VaR, the results for the three companies analyzed are in Table 4.

Table 4 *Marginal and component value at risk (VaR)*

		SSC		INS		PF	
Maturity	Risk factor	Marginal	Component (%)	Marginal	Component (%)	Marginal	Component (%)
1	Dollar	0.000	0.00	0.005	0.00	0.000	0.00
21	Foreign exchange linked rate	0.000	0.00	0.000	0.00	0.000	0.00
63	Foreign exchange linked rate	0.000	0.00	0.000	0.00	0.000	0.00
126	Foreign exchange linked rate	0.000	0.00	0.000	0.00	0.000	0.00
252	Foreign exchange linked rate	0.000	0.00	0.000	0.00	0.001	0.00
378	Foreign exchange linked rate	0.000	0.00	0.000	0.00	0.001	0.00
504	Foreign exchange linked rate	0.001	0.00	0.000	0.00	0.002	0.00
630	Foreign exchange linked rate	0.001	0.00	0.000	0.00	0.003	0.00
756	Foreign exchange linked rate	0.002	0.00	(0.000)	0.00	0.004	0.00
1008	Foreign exchange linked rate	0.003	0.00	(0.001)	0.00	0.006	0.00
1260	Foreign exchange linked rate	0.005	0.00	(0.002)	0.00	0.004	0.00
2520	Foreign exchange linked rate	0.008	0.00	0.000	0.00	(0.003)	0.12
1	IGP-M	0.079	0.00	(0.028)	-26.24	0.126	-42.16
63	IGP-M Linked rate	(0.002)	0.00	0.012	1.10	(0.001)	0.05
126	IGP-M Linked rate	(0.002)	0.00	0.016	1.68	0.008	-0.45
252	IGP-M Linked rate	0.002	0.00	0.017	2.12	0.019	-1.18
378	IGP-M Linked rate	0.010	0.00	0.014	1.54	0.030	-0.66
504	IGP-M Linked rate	0.017	0.00	0.010	1.38	0.039	-0.48
630	IGP-M Linked rate	0.023	0.00	0.007	0.82	0.047	0.68
756	IGP-M Linked rate	0.028	0.00	0.005	0.51	0.060	3.11
1008	IGP-M Linked rate	0.036	0.00	0.002	0.15	0.072	10.21
1260	IGP-M Linked rate	0.043	0.00	(0.001)	-0.20	0.154	24.34
2520	IGP-M Linked rate	0.087	0.00	(0.032)	0.33	0.231	29.99
3780	IGP-M Linked rate	0.130	0.00	(0.072)	-9.57	0.301	24.53
5040	IGP-M Linked rate	0.171	0.00	(0.109)	9.67	0.365	-0.13
6300	IGP-M Linked rate	0.209	0.00	(0.143)	10.06	0.426	-0.64
7560	IGP-M Linked rate	0.245	0.00	(0.176)	6.22	0.485	-0.67
8820	IGP-M Linked rate	0.281	0.00	(0.207)	3.43	0.543	-0.55
10080	IGP-M Linked rate	0.316	0.00	(0.238)	1.86	0.601	-0.39
11340	IGP-M Linked rate	0.351	0.00	(0.268)	0.96	0.659	-0.61
12600	IGP-M Linked rate	0.386	0.00	(0.298)	0.72	0.003	0.01
1	IPCA	0.006	8.05	0.033	58.99	0.004	-1.16
63	IPCA Linked rate	0.004	0.24	0.004	0.70	0.002	0.01
126	IPCA Linked rate	0.002	0.07	0.004	1.15	0.010	0.06
252	IPCA Linked rate	0.008	0.55	0.006	1.97	0.022	0.13
378	IPCA Linked rate	0.017	2.19	0.005	1.51	0.034	0.23
504	IPCA Linked rate	0.025	1.85	0.002	0.44	0.043	0.33
630	IPCA Linked rate	0.032	1.43	(0.001)	-0.20	0.053	0.53
756	IPCA Linked rate	0.040	4.03	(0.004)	-0.97	0.069	0.92
1008	IPCA Linked rate	0.052	6.49	(0.010)	-2.01	0.081	2.62
1260	IPCA Linked rate	0.062	14.79	(0.015)	-2.22	0.140	5.81
2520	IPCA Linked rate	0.109	23.09	(0.045)	6.51	0.193	6.21
3780	IPCA Linked rate	0.154	12.00	(0.076)	14.81	0.246	6.90

Table 4 *Cont.*

		SSC		INS		PF	
Maturity	**Risk factor**	**Marginal**	**Component (%)**	**Marginal**	**Component (%)**	**Marginal**	**Component (%)**
5040	IPCA Linked rate	0.205	12.12	(0.104)	11.00	0.297	6.41
6300	IPCA Linked rate	0.256	8.81	(0.122)	5.46	0.370	13.10
7560	IPCA Linked rate	0.326	14.35	(0.143)	0.52	0.432	10.51
8820	IPCA Linked rate	0.385	6.64	(0.155)	-6.58	0.479	1.67
10080	IPCA Linked rate	0.426	0.99	(0.160)	0.15	0.522	0.00
11340	IPCA Linked rate	0.460	0.00	(0.165)	0.25	0.563	0.00
12600	IPCA Linked rate	0.488	0.00	(0.170)	0.23	0.001	-0.02
1	RR	0.000	-0.09	(0.000)	0.02	0.000	0.02
63	RR Linked rate	0.000	0.07	0.000	0.00	0.003	-0.06
126	RR Linked rate	0.001	0.14	0.000	0.00	0.007	-0.13
252	RR Linked rate	0.003	-0.03	(0.000)	0.00	0.010	-0.12
378	RR Linked rate	0.005	-1.36	(0.001)	0.01	0.014	-0.07
504	RR Linked rate	0.007	-1.77	(0.002)	0.01	0.018	-0.04
630	RR Linked rate	0.009	-1.94	(0.004)	0.02	0.022	-0.03
756	RR Linked rate	0.011	-3.28	(0.005)	0.03	0.030	-0.03
1008	RR Linked rate	0.015	-5.40	(0.009)	0.07	0.037	-0.04
1260	RR Linked rate	0.018	-8.13	(0.011)	0.23	0.078	-0.13
2520	RR Linked rate	0.040	-3.07	(0.027)	0.55	0.116	-0.12
3780	RR Linked rate	0.061	-0.01	(0.040)	0.44	0.153	-0.09
5040	RR Linked rate	0.081	0.00	(0.053)	0.28	0.190	-0.06
6300	RR Linked rate	0.101	0.00	(0.065)	0.16	0.226	-0.04
7560	RR Linked rate	0.120	0.00	(0.077)	0.09	0.262	-0.02
8820	RR Linked rate	0.140	0.00	(0.089)	0.04	0.299	-0.01
10080	RR Linked rate	0.159	0.00	(0.101)	0.02	0.335	0.00
11340	RR Linked rate	0.179	0.00	(0.113)	0.01	0.371	0.00
12600	RR Linked rate	0.198	0.00	(0.125)	0.00	(0.006)	0.00
21	Fixed rate	0.000	0.00	(0.000)	0.00	0.000	0.00
63	Fixed rate	0.001	0.01	0.000	0.00	0.002	0.00
126	Fixed rate	0.003	0.03	(0.000)	0.01	0.004	0.00
252	Fixed rate	0.008	0.11	(0.001)	0.07	0.013	0.11
378	Fixed rate	0.015	1.84	(0.004)	-0.19	0.023	0.01
504	Fixed rate	0.022	2.35	(0.008)	-0.04	0.034	0.15
630	Fixed rate	0.028	0.29	(0.012)	0.37	0.044	0.02
756	Fixed rate	0.035	0.57	(0.017)	-0.10	0.054	0.55
1008	Fixed rate	0.047	-0.04	(0.024)	0.17	0.073	0.13
1260	Fixed rate	0.057	1.59	(0.031)	-0.45	0.090	0.17
2520	Fixed rate	0.099	0.46	(0.063)	-0.13	0.157	0.46
3780	Fixed rate	0.131	0.00	(0.093)	0.00	0.210	0.00
1	Stock	0.001	0.01	0.002	0.06	(0.001)	0.00
1	Commodities	(0.059)	0.00	0.019	0.00	(0.068)	0.00

SSC: special savings company; PF: pension fund; INS: insurer; IGP-M: Brazilian General Market Price Index; IPCA: Brazilian Consumer Price Index; RR: reference rate.

Source: *Elaborated by the authors.*

For the SSC, the maturities linked to the IPCA, despite not being the ones with the highest marginal VaR, are the ones that contributed most to the entity's total VaR. In the case of the INS, the maturity with the greatest weight in the total VaR is that of the IPCA rate, while for the pension fund it is the maturities linked to the IGP-M.

These results were obtained considering the covariance matrix with a July 2014 base date, adopted in CNSP Resolution n. 321 (Susep, 2015); however, the market changes over time, presenting periods of higher and lower volatility for the various risk factors considered. In order to maintain adherence to the market reality, the information in the covariance matrix should be updated, reflecting the supervised entities' real solvency risk.

Thus, this paper sought to estimate the impact of a possible updating of the covariance matrix with the data up to December 2015, considering the TSIR curves available from the Susep website (Susep, 2015), and contemplating the volatility in the economic scenario occurring during the electoral period of 2014 and Brazil's loss of investment

grade status. This updating tends to better reflect the current scenario, and consequently, better estimate the market risk incurred by the market participants.

With the updating of the covariance matrix, an increase is observed for the market risk capital of the three companies, due to the increase in volatility for the period, with the impact being more accentuated in the SSC, whose need for capital doubles. The results are presented in Table 5.

Table 5 *Required capital with updating of the assumptions*

	SSC (%)	INS (%)	PF (%)
VaR	6.37	0.43	2.34

SSC: special savings company; PF: pension fund; INS: insurer; VaR: value at risk.
Source: *Elaborated by the authors.*

The SSC has an expressive increase in required capital with the change in the covariance matrix used. The increase in capital is presented in Table 6.

Table 6 *Increase in required capital with update*

	SSC (%)	INS (%)	PF (%)
VaR	95.70	9.67	7.81

SSC: special savings company; PF: pension fund; INS: insurer; VaR: value at risk.
Source: *Elaborated by the authors.*

The marginal VaR and the component VaR for the three companies are presented in Table 7.

Table 7 *Marginal and component value at risk (VaR) with new matrix*

		SSC		INS		PF	
Maturity	**Risk factor**	**Marginal**	**Component (%)**	**Marginal**	**Component (%)**	**Marginal**	**Component (%)**
1	Dollar	0.007	0.00	0.064	0.00	(0.078)	0.00
21	Foreign exchange linked rate	(0.000)	0.00	(0.000)	0.00	(0.000)	0.00
63	Foreign exchange linked rate	0.000	0.00	(0.000)	0.00	0.000	0.00
126	Foreign exchange linked rate	0.002	0.00	(0.003)	0.00	0.003	0.00
252	Foreign exchange linked rate	0.001	0.00	(0.005)	0.00	0.007	0.00
378	Foreign exchange linked rate	0.000	0.00	(0.005)	0.00	0.009	0.00
504	Foreign exchange linked rate	(0.001)	0.00	(0.007)	0.00	0.011	0.00
630	Foreign exchange linked rate	(0.001)	0.00	(0.009)	0.00	0.013	0.00
756	Foreign exchange linked rate	(0.001)	0.00	(0.011)	0.00	0.014	0.00
1008	Foreign exchange linked rate	(0.001)	0.00	(0.015)	0.00	0.018	0.00
1260	Foreign exchange linked rate	(0.001)	0.00	(0.018)	0.00	0.020	0.00
2520	Foreign exchange linked rate	(0.002)	0.00	(0.005)	0.00	0.015	0.00
1	IGP-M	0.003	0.00	0.001	0.91	0.002	-0.66
63	IGP-M Linked rate	0.000	0.00	0.005	0.48	(0.001)	0.04
126	IGP-M Linked rate	0.001	0.00	0.007	0.72	0.001	-0.03
252	IGP-M Linked rate	0.001	0.00	0.008	1.04	0.006	-0.30
378	IGP-M Linked rate	0.002	0.00	0.006	0.66	0.009	-0.53
504	IGP-M Linked rate	0.004	0.00	0.003	0.46	0.013	-0.27
630	IGP-M Linked rate	0.005	0.00	0.001	0.08	0.018	-0.21
756	IGP-M Linked rate	0.007	0.00	(0.002)	-0.24	0.024	0.32
1008	IGP-M Linked rate	0.010	0.00	(0.009)	-0.74	0.036	1.75
1260	IGP-M Linked rate	0.013	0.00	(0.016)	-2.78	0.048	6.32
2520	IGP-M Linked rate	0.022	0.00	(0.052)	0.57	0.102	14.96
3780	IGP-M Linked rate	0.030	0.00	(0.089)	-12.69	0.153	18.41
5040	IGP-M Linked rate	0.041	0.00	(0.139)	13.18	0.220	16.63
6300	IGP-M Linked rate	0.055	0.00	(0.203)	15.18	0.302	-0.10
7560	IGP-M Linked rate	0.070	0.00	(0.274)	10.31	0.392	-0.55
8820	IGP-M Linked rate	0.085	0.00	(0.348)	6.15	0.484	-0.62

Table 7 *Cont.*

		SSC		INS		PF	
Maturity	**Risk factor**	**Marginal**	**Component (%)**	**Marginal**	**Component (%)**	**Marginal**	**Component (%)**
10080	IGP-M Linked rate	0.101	0.00	(0.423)	3.53	0.576	-0.54
11340	IGP-M Linked rate	0.116	0.00	(0.498)	1.91	0.668	-0.40
12600	IGP-M Linked rate	0.131	0.00	(0.574)	1.49	0.760	-0.65
1	IPCA	0.002	1.28	0.003	5.78	(0.001)	0.13
63	IPCA Linked rate	0.001	0.02	0.003	0.66	0.002	0.00
126	IPCA Linked rate	0.001	0.02	0.007	2.16	0.003	0.01
252	IPCA Linked rate	0.003	0.13	0.007	2.71	0.007	0.04
378	IPCA Linked rate	0.007	0.44	0.006	2.11	0.014	0.07
504	IPCA Linked rate	0.010	0.36	0.003	0.80	0.022	0.14
630	IPCA Linked rate	0.013	0.28	(0.000)	-0.07	0.029	0.21
756	IPCA Linked rate	0.015	0.76	(0.004)	-1.06	0.034	0.32
1008	IPCA Linked rate	0.018	1.15	(0.012)	-2.61	0.044	0.54
1260	IPCA Linked rate	0.020	2.49	(0.019)	-3.09	0.053	1.57
2520	IPCA Linked rate	0.032	3.48	(0.061)	9.48	0.100	3.84
3780	IPCA Linked rate	0.048	1.90	(0.107)	22.18	0.158	4.71
5040	IPCA Linked rate	0.066	1.98	(0.154)	17.36	0.218	5.66
6300	IPCA Linked rate	0.084	1.48	(0.198)	9.44	0.278	5.57
7560	IPCA Linked rate	0.103	2.32	(0.241)	0.94	0.337	11.08
8820	IPCA Linked rate	0.122	1.08	(0.282)	-12.76	0.396	8.93
10080	IPCA Linked rate	0.142	0.17	(0.321)	0.31	0.454	1.47
11340	IPCA Linked rate	0.163	0.00	(0.359)	0.59	0.511	0.00
12600	IPCA Linked rate	0.183	0.00	(0.395)	0.57	0.567	0.00
1	RR	(0.094)	78.53	(0.033)	3.52	0.023	1.76
63	RR Linked rate	(0.000)	-0.02	(0.000)	0.00	0.001	-0.01
126	RR Linked rate	(0.000)	-0.03	(0.000)	0.00	0.002	-0.03
252	RR Linked rate	(0.000)	0.00	(0.001)	0.01	0.004	-0.08
378	RR Linked rate	(0.000)	0.06	(0.002)	0.01	0.007	-0.08
504	RR Linked rate	(0.000)	0.07	(0.004)	0.02	0.010	-0.05
630	RR Linked rate	(0.001)	0.07	(0.006)	0.03	0.014	-0.03
756	RR Linked rate	(0.001)	0.13	(0.009)	0.05	0.018	-0.02
1008	RR Linked rate	(0.001)	0.25	(0.015)	0.12	0.025	-0.02
1260	RR Linked rate	(0.002)	0.41	(0.021)	0.44	0.033	-0.03
2520	RR Linked rate	(0.002)	0.09	(0.048)	1.03	0.067	-0.10
3780	RR Linked rate	(0.001)	0.00	(0.071)	0.81	0.102	-0.10
5040	RR Linked rate	0.000	0.00	(0.094)	0.53	0.139	-0.08
6300	RR Linked rate	0.002	0.00	(0.118)	0.30	0.177	-0.06
7560	RR Linked rate	0.004	0.00	(0.143)	0.17	0.216	-0.03
8820	RR Linked rate	0.006	0.00	(0.168)	0.09	0.255	-0.02
10080	RR Linked rate	0.008	0.00	(0.193)	0.04	0.293	-0.01
11340	RR Linked rate	0.010	0.00	(0.219)	0.02	0.331	0.00
12600	RR Linked rate	0.012	0.00	(0.244)	0.01	0.368	0.00
21	Fixed rate	(0.000)	0.00	(0.000)	0.01	0.000	0.00
63	Fixed rate	0.000	0.00	(0.000)	0.04	0.001	0.00
126	Fixed rate	0.001	0.00	(0.000)	0.06	0.003	0.00
252	Fixed rate	0.002	0.02	(0.002)	0.12	0.008	0.06
378	Fixed rate	0.005	0.30	(0.005)	-0.25	0.015	0.01
504	Fixed rate	0.007	0.37	(0.010)	-0.06	0.022	0.09
630	Fixed rate	0.008	0.04	(0.016)	0.53	0.030	0.01
756	Fixed rate	0.010	0.08	(0.023)	-0.15	0.039	0.37
1008	Fixed rate	0.012	0.00	(0.036)	0.27	0.055	0.09
1260	Fixed rate	0.014	0.20	(0.049)	-0.75	0.071	0.12
2520	Fixed rate	0.025	0.06	(0.105)	-0.23	0.142	0.39
3780	Fixed rate	0.036	0.00	(0.157)	0.00	0.214	0.00
1	Stock	0.010	0.04	(0.066)	-2.52	0.108	0.00
1	Commodities	(0.151)	0.00	(0.097)	0.00	(0.370)	0.00

SSC: special savings company; PF: pension fund; INS: insurer; IGP-M: Brazilian General Market Price Index; IPCA: Brazilian Consumer Price Index; RR: reference rate.

Source: *Elaborated by the authors.*

With the change in the covariance matrix used, not only the capital requirement changes, but also the evaluation regarding which strategies to use to manage each entity's VaR.

For the SSC, the main factor contributing to the VaR is the RR, while in the calculation with the matrix up to July 2014 it was the IPCA maturities.

In the case of the INS, the greatest contribution to the VaR changes from the IPCA rate to the intermediate IPCA maturities, with the new matrix. As for the PF, the VaR results indicate the intermediate IGP-M maturities as the greatest contribution to VaR with both matrices.

Given the regulatory model adopted, Susep's concern is observed in relation to the risk of decay of risk factors and periods between assets and liabilities, given that the VaR calculation is applied to net exposures, which highlights the importance of ALM practices. Currently, market risk management in many of the supervised entities is geared towards evaluating and monitoring the variation in the value of financial investments in isolation, without observing the behavior of the respective liabilities. Therefore, conservative practices for market risk adopting the restricted perspective of financial assets (for example, concentrating portfolio investments into low volatility government bonds, such as Financial Treasury Bills) may not be the ones that result in the lowest capital allocation, which represents a new challenge for the risk managers of these companies.

It is worth mentioning, however, that the investment aims of the regulated entities can go beyond simply reducing required capital. It is common to find, for example, investment strategies that aim, via allocation into assets indexed to the IPCA, to address liabilities indexed to the RR, seeking the potential financial gains to the detriment of the need for market risk capital. Moreover, ALM practices often consider the assumption of new business instead of a run-off company, despite this being a concept embedded into the regulatory model.

All of these challenges make the current need to use the ALM apparent in order to address the different aims encountered, whether these are required by the regulator, or are derived from market operations.

5. CONCLUSIONS

The introduction of market risk capital regulations for INSs, PFs, SSCs, and reinsurers leads to various challenges for the market, not only from a financial impact perspective, but also for aspects of management and regulation.

The results presented in the cases studied in this paper show that there is an impact for the entities and that this impact can lead to large variations, depending on the assumptions used.

The covariance matrix used for the purposes of calculating the regulatory capital for market risk was updated only up to July 2014 and did not capture the effect of the volatility of the current Brazilian market, which may be underestimating risk, as shown in this paper's result, given that this date precedes the electoral period and the loss of investment grade status, which are, for example, events that contributed to an increase in volatility.

The financial impact of the introduction of market risk capital tends to incentivize changes in management practices, especially in relation to the ALM, remembering that asset and liability management is a much broader concept that merely pairing assets and liabilities. There is a need to understand and define the aim of the ALM, such as: (i) to optimize regulatory capital, (ii) to optimize economic capital, and (iii) to optimize financial return, observing a capital budget etc. The establishment of an ALM practice was also included in the rule that addresses enterprise risk management (ERM), published in Susep Circular Letter n. 517 (Susep, 2015), and altered by Susep Circular Letter n. 521 (Susep, 2015).

The rule for market risk capital also tends to influence the way companies engage in market risk management, which usually only emphasizes financial assets, coming to incorporate a more holistic view of risk and simultaneously analyzing assets and liabilities. This should even influence the organizational structures of companies, requiring more interaction between investment and actuarial areas.

Therefore, given the relevance of the topic that is the object of this research and its consequences, the need for more research into this is observed.

For future studies, we suggest developing other conceptual studies, such as:

- The solvency time horizon is different for each type of risk; therefore, what is the concept of the aggregated view for regulatory capital?
- Is there interest rate risk overlapping between the market risk capital model and the subscription risk one for PFs?
- When will the internal model be regulated?

Moreover, we recommend that future studies explore another topic that relates to this research, regarding the measurement of liabilities broken down into "current estimates" and "margin over the current estimates" (MOCE).

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