Economies of scale in Brazilian closed supplementary pension entities: is there an optimal size?

Economias de escala nas entidades fechadas de previdência complementar brasileiras: existe um tamanho ótimo?

Economías de escala en las entidades de pensiones privadas brasileñas: ¿hay un tamaño óptimo?

Rudolph Fabiano Alves Pedroza Teixeira*
Doutorando em Ciências Contábeis (UFRJ)
Profissional da Nível Superior da Centrais Elétricas
Brasileiras (ELETROBRAS), Rio de Janeiro/RJ, Brasil
rudolphteixeira@gmail.com
http://orcid.org/0000-0001-5325-5267

Adriano Rodrigues
Doutor em Controladoria e Contabilidade (USP)
Professor do Programa de Pós-Graduação em Ciências
Contábeis (UFRJ), Rio de Janeiro/RJ, Brasil
adriano@facc.ufrj.br
https://orcid.org/0000-0002-0099-0505

Primary contact address for correspondence*
Avenida Pasteur 250, Sala 250, Urca, CEP: 22.290-240 – Rio de Janeiro/RJ, Brasil

Abstract
This research investigated the existence of an optimal size for the operation of Brazilian Closed Supplementary Pension Entities (CSPE), based on their administrative expenses. Otherwise stated, we verified whether the Brazilian pension funds would benefit from economies of scale up to a certain point, after which the complexity of the large structures would cause diseconomies of scale. As a background, we used the theory of industrial organization with a focus on entry barriers. The results showed that CSPE administrative expenses behave in a "U" shape, which means that there is an optimal size for these entities' operation. This finding provides important elements to subsidize the industry's regulatory body to restrict the entry of new funds in this market, which would benefit all CSPE participants in cost reduction and expansion of social security savings.
Keywords: Entry Barriers; Administrative Expenses; Economies of Scale; CSPE; Optimal Size

Resumo
A pesquisa investigou a existência de um tamanho ótimo para a operação das Entidades Fechadas de Previdência Complementar (EFPC) brasileiras, com base em suas despesas administrativas. Em outras palavras, foi verificado se os fundos de pensão brasileiros gozariam de economias de escala até um determinado ponto, a partir do qual, a complexidade das grandes estruturas passaria a provocar deseconomias de escala. Como pano de fundo foi utilizada a teoria da organização industrial com enfoque nas barreiras à entrada. Os resultados comprovaram que as despesas administrativas das EFPC se comportam na forma de "U", o que significa que existe um tamanho ótimo para operação dessas entidades. Esse achado fornece importantes elementos que podem subsidiar o órgão regulador do setor a restringir a entrada de novos fundos nesse mercado, o que traria benefícios a todos os participantes das EFPC em termos de redução de custos e ampliação da poupança previdenciária.
Palavras-chave: Barreiras à Entrada; Despesas Administrativas; Economias de Escala; EFPC; Tamanho Ótimo

Resumen
La presente investigación investigó la existencia de un tamaño óptimo para la operación de las Entidades de Pensiones Complementarias Cerradas de Brasil (EPCC), con base en sus gastos administrativos. En otras palabras, se verificó si los fondos de pensiones brasileños disfrutarían de economías de escala hasta cierto punto, después de lo cual, la complejidad de las grandes estructuras causaría deseconomías de escala. Como antecedente, se utilizó la teoría de la organización industrial con un enfoque en las barreras de entrada. Los

resultados demostraron que los gastos administrativos de EPCC se comportan en forma de "U", lo que significa que hay un tamaño óptimo para la operación de estas entidades. Este hallazgo proporciona elementos importantes que pueden subsidiar el organismo regulador del sector para restringir la entrada de nuevos fondos en este mercado, lo que traería beneficios a todos los participantes de EPCC en términos de reducción de costos y expansión de los ahorros de la seguridad.

Palabras clave: Barreras a la entrada; Gastos administrativos; Economías de escala; EPCC; Tamaño óptimo

1 Introduction

Closed Supplementary Pension Entities (CSPE), or pension funds, are organizations created as non-profit civil societies or foundations that have the function of administering collective pension plans. CSPE are accessible only to a sponsor's employees/servants or to individuals who have a relationship with a settlor (Complementary Law no. 109, 2001).

These entities have enormous social responsibility. Besides guarding the resources of more than 3.5 million people in Brazil (Brazilian Association of Closed Supplementary Pension Entities, 2019), CSPE are also responsible for managing and applying these resources efficiently and effectively, seeking a balance between risk and return, in keeping with the guidelines of Resolution No. 4.661, dated May 25th, 2018, issued by the National Monetary Council (CMN).

However, the creation and maintenance of CSPE require resources to cover various administrative expenses, such as benefit plans, investment portfolio, employee salaries, attorney services, actuarial and financial consultancy, information technology (IT) services, among others (Bateman & Mitchell, 2004).

In this sense, the efficient management of administrative expenses is a relevant topic for the defense interests of participants', sponsors', and settlors', since the resources used in pension funds' maintenance no longer enter the social security savings of post-employment benefit plans (National Superintendence of Supplementary Pension, 2020c).

In this regard, Ambachtsheer (2010) stated that CSPE economies of scale play a fundamental role in providing good retirement benefits, as funds with lower administrative expenses *per capita* would be responsible for maximizing their participants' accumulated wealth, given they would spend less on its maintenance.

A key aspect to the economies of scale is the portion of fixed costs. According to Besanko *et al.* (2009), these costs would be diluted by expanding production, compensating for the variable costs' constant behavior, which would decrease unit cost. In the case of pension funds, Bikker and De Dreu (2009) stated that fixed costs, due to their inelasticity concerning the number of participants and financial assets, represent a large portion of the unexplored economies of scale, mainly due to activities such as communication, compliance, accounting and regulatory obligations, IT systems, etc.

However, Bikker (2017) also pondered that, due to this apparent high-cost inelasticity, theoretical and empirical research on CSPE focus on describing the cost function as a monotonic decline. For this author, some funds may be operating above their productive capacity, generating diseconomies of scale for their participants.

Part of the literature linked to the industrial organization provided evidence that large companies' costs may increase more than proportionally after reaching a certain size. This means that unit costs would not continuously decrease in the face of the quantity produced, but behave in the form of a "U." For example, Griffin and Tversky (1992) argued that the scarcity of qualified personnel, the increased luxury in corporate buildings, and executives' high salaries can generate additional costs for large companies.

Canback, Samouel, and Price (2006) considered that employees' commitment may be lower in large businesses, considering that they would contribute little to the organization's success, resulting in less productivity. Bauer, Cremes, and Frehen (2010) mentioned that the communication between different departments and the need to monitor employees in large companies increase costs. Moreover, Chatterton, Smyth, and Darby (2010) affirmed that the big businesses' inefficiency can originate from the bureaucracy linked to these entities' complex organizational charts, which would include different hierarchical levels to manage.

This research aimed to investigate whether there is an optimal size for the operation of Brazilian CSPE based on their administrative expenses. Otherwise stated, we intended to verify whether the Brazilian pension funds would benefit from economies of scale up to a certain point, after which the complexity of the large structures would cause diseconomies of scale.

The present study's rationale was the need to provide elements to the National Council for Supplementary Pension (CNPC), this industry's regulatory body, regarding the creation of new entry barriers in this market, fostering its concentration. Andrews (1981), Bateman and Mitchell (2004), Bikker and De Dreu (2009), and Cunha (2018) proved the existence of economies of scale in the closed supplementary pension industry when considering a cost function with monotonic behavior. However, to our knowledge, the study by Bikker (2017) regarding Dutch CSPE is the only one that calculated the optimal size for the closed

supplementary pension market considering a "U" behavior for its costs. Thus, the present research should also help to fill this gap in Brazilian literature.

For this purpose, we replicated the study by Bikker (2017) and tested four types of U-shaped quadratic cost functions to explain administrative expenses and with pension fund investments in Brazil. Concerning social security expenses, we used the total number of participants (active and inactive) as the main input of the equations, that is, the fund's total population, which captures social security management. In turn, for investment expenses, the main variable was the total financial assets of CSPE, which represent the portion linked to financial management.

2 The Main Characteristics of Brazilian CSPE

According to Pereira, Niyama, and Sallaberry (2013) and Pasqualeto (2015), Brazil's supplementary pension scheme is divided into two types. The first comprises open supplementary pension entities (OSPE), organized as joint-stock corporations managed by financial institutions and insurance companies, and accessible to all citizens. The second refers to CSPE, created as a non-profit civil society or foundation, accessible to public or private companies' employees and officials from the Federal Government, Federal District (DF), States, municipalities, and their independent agencies and foundations. These federal entities are called sponsors. Also, this system includes associates of professional, class, or industry legal entities, called settlors.

Concerning CSPE, the great advantage for its participants lies not only in the resources they contribute to their social security savings but also in the contributions made by the sponsors, which, in most cases, are equal to those made by the participants, generating a catalytic effect on the volume of accumulated resources.

As shown in Table 1, between 2017 and 2018, Brazilian CSPE had an average of 2.95 million participants – active and inactive (retirees and pensioners) – with over BRL 861.5 billion in invested resources. Additionally, each participant had, for the same period, an accumulated average of BRL 292 thousand among over 940 post-employment benefit plans offered by the analyzed CSPE[i].

Table 1:
Main Statistics of Brazilian CSPE

Description	2017	2018
Total Social Security Expenses (in BRL billions)	1.86	1.78
Total Investment Expenses (in BRL billions)	1.14	1.15
Administrative expenses *per capita* (BRL thousand)	1.05	0.97
Number of Participants (in millions)	2.87	3.03
Total Assets (in BRL billions)	842.54	880.52
Administrative Expenses on Total Assets	0.22%	0.20%
Assets *per capita* (BRL thousand)	294.03	290.40
Average Maturity (benefits to be granted/granted)	7.14	5.24
Average Solvency (mathematical prov./coverage equity)	1.07	1.03
DC Plans	399	416
DB Plans	279	230
VC Plans	294	295
Outsourcing on Administrative Expenses (average)	33.97%	40.27%
Total CSPE	225	230
Federal Public CSPE	33	33
State Public CSPE	36	36
Municipal Public CSPE	2	2
Private CSPE	138	143
Settlor CSPE	16	16
CSPE in RJ, SP, and DF	140	144
CSPE in other regions	85	86

Note: The 2017 figures were adjusted based on the 2018 National Consumer Price Index (INPC)
Source: Elaborated by the authors based on PREVIC (2020a), (2020b), and (2020c).

It is noteworthy that, in the 2017-2018 period, over 62% of CSPE were located in three of the main Brazilian capitals (i.e. Rio de Janeiro, São Paulo, and Brasília) with 61% of all CSPE maintained by private companies, while predominantly state-sponsored CSPE accounted for approximately 31% of all pension funds.

Regarding the type of plan offered by these entities, most of them appear to be concentrated in the defined contribution (DC) modality, followed by the variable contribution (VC) and defined benefit (DB) plans, with a growth trend over time for the first when compared to the latter two, which present, in their essence, actuarial risks. This fact is supported by the Interministerial Commission for Corporate Governance and Management of Federal Corporate Interest (CGPAR) Resolution No. 25, dated December 6th, 2018, Article III, which determines the creation of new plans by state-owned companies in the DC mode only.

Regarding administrative efficiency in the 2017-2018 period, the CSPE spent an average of BRL 1.82 billion on pension management, which comprises the set of activities related to serving its participants, and

BRL 1.14 billion on the management of all their investments, which, on a consolidated basis, represented an average administrative expense *per capita* of over BRL 1 thousand per year.

We also calculated CSPE maturity and solvency, as recommended by the National Association of Pension Entity Accountants (ANCEP, 2020). Maturity is given by the total benefits to be granted over the granted total benefits and indicates the rate of resources maintained by active participants compared to inactive participants' resources. A maturity of less than 1 (one) shows that the fund has more resources committed to paying inactive participants than what is kept in reserve by the active participants. In 2017, there were about seven-fold resources to be granted by CSPE than the amounts already granted. This proportion was around five to one in 2018.

For the solvency, which is obtained by dividing the total mathematical provisions by the CSPE coverage equity, a value greater than 1 (one) indicates insufficient resources to pay full benefits to all participants. Considering the period 2017-2018, this indicator was higher than the unit, revealing that the market CSPE are insolvent on average.

3 The Classical Theory of Industrial Organization and Entry Barriers

In the search for efficiency and competitiveness, companies must be able to assess and find their performance's main determinants to implement strategic actions that put them at an advantage over their established competitors and potential inbound competitors which may benefit the entire industry (Kupfer, 2002).

In each industrial segment, the entry of new competitors is hampered by certain entry barriers, which may be higher or lower, depending on the industry in question. Thus, adequate knowledge of these barriers becomes essential for companies to adopt appropriate survival strategies.

Bain (1956) defined the concept of entry barriers in a given market as the initial distinction between established businesses, which produce to serve their market, and businesses not yet established in an industry, which have an interest in building new plants to try and compete with companies already installed. However, Kon (1994) considered that the entry condition is the "disadvantage" of businesses with potential entry compared to the established businesses.

In his study, Bain (1956) gave great importance to the level of entry barriers. His theoretical contributions were responsible for the framework that allowed the construction of the Structure-Conduct-Performance (S-C-P) paradigm, which is an instrument derived from the Theory of Industrial Organization, created to show the variables that influence companies' economic performance (Scherer & Ross, 1990).

According to Possas (1987), S-C-P models evaluate the characteristics of the market structure to demonstrate its influence on businesses' performance. Among the variables that determine an industry's structure, some entry barriers can significantly influence a new competitor's chances to enter the market, depending on these barriers' size and intensity.

The statements regarding the possibility that companies belonging to an industry with high entry barriers can charge higher prices led Bain (1956) to formulate the Theory of Limit Pricing, in which the limit price means the maximum amount that can be charged by the combination of incumbent companies without inducing the entry of competitors (Koutsoyiannis, 1985). Therefore, the limit price has a direct relationship with entry conditions into an industry (entry barriers): the higher the limit price, the greater the entry barriers, resulting in the expansion of companies' earnings in the industry. Mathematically, we can express this relationship through Equation 1.

$$E = \frac{(P_L - P_C)}{P_C} \qquad (1)$$

Where: E refers to entry conditions or barriers; P_L is the limit price, that is, the maximum price charged without attracting new competitors; and P_C is the price charged in a competitive market, that is, with normal profits.

Rewriting Equation 1, we have $P_L = P_C(1 + E)$, showing that, the more difficult it is for new competitors to enter, the higher the price charged by established companies. Thus, it appears that, even though this theory was initially developed to address companies' behavior in oligopolized markets, the market industry's literature admits that the existence of entry barriers to a greater or lesser extent is capable of directly influencing competition in any type of industry, affecting its competitive performance (Scherer & Ross, 1990).

In this regard, the Brazilian supplementary pension market has two rates or prices that impact the incumbent funds' income: the load and administration fees. The first concern the monthly resource contributions made by the participant and/or the sponsor, and it can also concern benefit payment in the post-employment period. The second is an annual fee based on the participant's assets throughout their life (Private Insurance Superintendence, 2017).

A relevant aspect regarding the limit price that can be practiced by Brazilian CSPE is provided for in Resolution no. 29, dated August 31st, 2009, of the former Complementary Pension Management Council (CGPC), currently CNPC, which, in its Article VI, provides for the maximum percentages for these two rates:

Art. VI The annual limit of resources destined by the set of benefit plans executed by CSPE referred to Complementary Law No. 108, dated 2001, for the administrative management plan, observing the costing by the sponsor, participants, and beneficiaries, is one of the following:
I - administration fee of up to 1% (one percent); or
II - load fee of up to 9% (nine percent)" (CGPC, 2009).

Otherwise stated, in the closed supplementary pension market, the limit price is not given by collusive conduct among the incumbent businesses, but by an order that emanates from the regulatory body, limiting the possibilities of collecting CSPE for its maintenance to a certain level.

In turn, to better understand the elements presented in Bain's limit pricing analysis (1956) and its impact on CSPE, one must address four types of barriers to entry the industry, namely: a) investment need (high initial capital); b) product differentiation; c) absolute cost advantages; and d) economies of scale (Kupfer, 2002).

3.1 Need for High Initial Investments

When a company's entry in a given market requires a substantial initial investment, there is an entry barrier (Bain, 1968). This type of obstacle is directly related to entrepreneurs' difficulty in financing large investments, which require a significant amount of resources for their initial implementation (Kupfer, 2002).

According to Kupfer (2002), the general initial sunk costs of most large investments influence the companies' strategic behavior and the formation of their market price. More specifically, Almeida (2009) considered that large non-refundable or irrecoverable investments are those that enable large incumbent companies to charge prices equal to their marginal cost, allowing them to have competitive advantages by being able to quickly meet expanding demands.

For the closed supplementary pension market, the initial investment for creating a new pension fund is the sponsor's responsibility, who must pay the necessary amount to implement the new CSPE. As an example, Law No. 12.618, dated April 30th, 2012, Art. XXV, authorized the Federal Government to contribute the initial amount of BRL 50 million to the creation of Funpresp-Exe, BRL 25 million for Funpresp-Leg, and BRL 25 million for Funpresp-Jud, which are the pension funds of the executive, legislative, and judicial branches.

Therefore, it appears that high initial investments would also be an entry barrier into the closed supplementary pension market since, in addition to having to bear part of the participants' contributions and the fund's monthly cost, the sponsor would need to contribute a significant initial amount for the creation of a new CSPE.

A strategy that many companies have used to escape the high initial investments, and that leads to a greater concentration of this market, is the sponsorship of existing post-employment CSPE benefit plans customized according to the new sponsors' interests.

As a supplementary incentive to these new sponsors, the CNPC issued Resolution No. 35, dated December 20th, 2019, Art. IV, single paragraph, determines that, in the multi-sponsored entities, the choice of sponsors' representatives for the deliberative council and audit committee should consider the sponsors with the largest number of participants and those that have the largest guaranteed resources in the pension plans.

Otherwise stated, it is clear that, in practice, in addition to the natural barrier related to high initial investments, the regulatory body also guaranteed a privileged position in the governance of funds for companies that have more participants and invested resources, promoting the formation of social security savings in already created CSPE.

3.2 Product Differentiation

Product differentiation can act as an entry barrier when differences in quality and design lead to consumer loyalty toward products manufactured by established companies (Maluf, 2002). In such a situation, the barrier exists because entrant businesses either need to sell their new products at a lower price than the incumbent ones or invest a considerable amount in advertising to publicize their brand to position themselves competitively (Kupfer, 2002).

According to Kon (1994), the price decrease strategy has the disadvantage of damaging the entrant company's profitability, which is difficult to maintain in the long run. In turn, high advertising expenditure leads to an increase in the entrant's average costs, which, in practice, means an absolute cost advantage for established companies.

In a complementary way, Porter (1985) stated that product differentiation coupled with cost reduction is a generic strategy used by incumbent companies in a given market to create barriers to new competitors' entry, shielding the market share of established businesses.

For these reasons, Bain (1956) considered product differentiation as one of the strongest barriers to new competitors' entry in the market, as incumbent businesses know the consumers' preferences and direct production to satisfy their customers' desires.

In closed supplementary pensions, CSPE customize their pension plans to serve their sponsors, who have certain preferences regarding the plan's design and regulations. Currently, companies sponsoring post-employment benefit plans demand that the funds decrease actuarial risks and fight against occasional deficits. The public and mixed capital agencies and companies, for instance, should close their current DB plans, subject to actuarial risks, and propose only DC modality plans to its participants, as determined by CGPAR Resolution No. 25 dated 2019 in Articles III and IV.

Additionally, Resolution No. 25, Art. VI, single paragraph, determines that state-owned companies should propose to their director board the transfer of benefit plan management if there is no cost-effectiveness in their maintenance by the CSPE managing them. Such a transfer can provide a possibility to any CSPE entering the market, as long as the current CSPE do not maintain a product differentiation policy to satisfy their sponsors.

3.3 Absolute Cost Advantages

Differences in the cost structure between incumbent and incoming businesses become entry barriers when the former have absolute cost advantages over the latter (Koutsoyiannis, 1985). According to Kupfer (2002), these advantages would be due to the exclusive access that established companies would have over certain assets and resources, which would allow them to manufacture the same products as a potential entrant at a similar production scale and lower cost.

More specifically, Koutsoyiannis (1985) considered that incumbent companies' cost advantages lie in three facts: a) incoming businesses would need to pay higher wages to attract specialized personnel; b) incoming businesses do not have patents and advanced techniques available; and c) incumbent businesses already have consolidated vertical integration within the supply chain.

In the closed supplementary pension market, the established CSPE have absolute cost advantages due to the restricted supply of qualified labor (lawyers, actuaries, accountants, financial analysts, etc.). Established CSPE may deal with regulatory, investment, and remodeling plans, among other issues; and because the technology used to control the asset, pension, and investment management is specific to the industry, not being obtained or customized by any IT company in the short term.

3.4 Economies of Scale

Individual businesses' size is a determinant for maximizing efficiency (Bain, 1956). According to Besanko *et al.* (2009), economies of scale imply a decrease in the average costs in established companies as production increases. Therefore, for a potential entrant to compete on an equal footing with established businesses, it must start operations with a minimum efficient scale (MES) that guarantees an average cost similar to that of incumbent businesses.

The MES means the size necessary for a business to minimize its unit costs so that it uses all its potential to economies of scale (Koutsoyiannis, 1985). Besanko *et al.* (2009) stated that three basic possibilities represent the occurrence of economies of scale in companies (Figure 1).
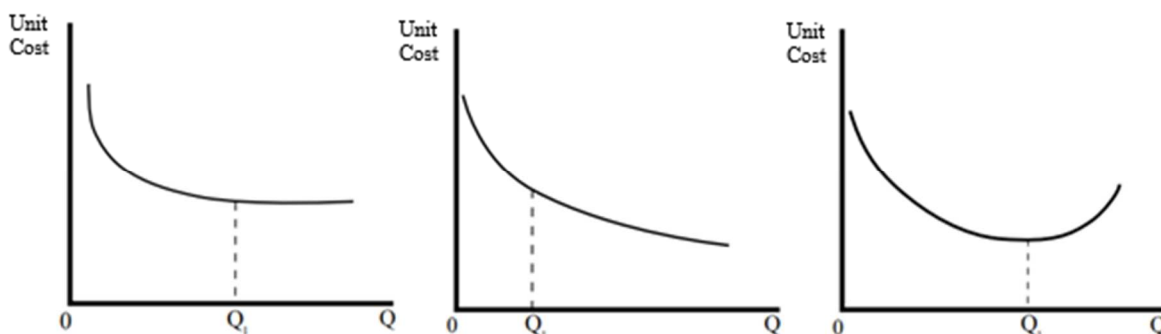

Figure 1: Possibilities for Economies of Scale
Source: Elaborated by the authors based on Koutsoyiannis (1985).

The first possibility comprises the L-shaped cost curve, in which the increase in production would cause a drop in the average cost up to a quantity Q_1, where, from then on, the business would always operate at its minimum cost. The second possibility concerns the monotonically decreasing average cost curve, in which economies of scale are in force indefinitely throughout all production, with no productive bottlenecks. Lastly, the third possibility approaches the U-shaped cost curve, in which production increases would provide

for decreasing costs up to Q_1, where, from then on, any further increase in production would trigger an upward cost trajectory.

Considering the CSPE market, the decrease in unitary terms of administrative expenses can provide greater well-being to active, inactive, and pensioner participants, since a greater portion of resources will be destined to the creation of social security assets, considering the CSPE maintenance (Bateman & Mitchell, 2004).

However, when the same entity has a lower cost to offer two services, such as pension plans and payroll deductible loans, compared to the cost of these services offered individually by different companies, the participants' possibilities increase, since they will be paying less on a *pro-rata* basis for a larger basket of services.

The two main services offered by CSPE are pension management and asset management (investments). In general, the performed econometric studies use two proxies to represent these services in their models: the number of participants and the total volume of financial assets of an CSPE (Bikker, 2017).

These two variables, when used in the same equation, can measure economies of scale if unit costs decline in tandem with the increase in CSPE participants and asset volume (Bikker & De Dreu, 2009). In statistical terms, if the number of participants and asset volume coefficients are less than 1 (one), there are economies of scale in the CSPE administrative expenses (Malhotra, Martin & Mcleod, 2009).

Caswell (1976) was the first to explain the administrative expenses determinants in CSPE using cross-section data from the US construction industry's pension plans in the 1969-1970 biennium. The author found that the number of participants was a relevant variable to explain the CSPE economies of scale, obtaining a coefficient value of 0.8 for this variable.

Mitchell and Andrews (1981), when applying a cross-section regression with data from CSPE sponsored by US private sector companies in 1975, found that, in addition to the number of participants, another important variable for the occurrence of economies of scale in CSPE was the total financial assets of these entities. In their model, these authors found the coefficient values of 0.56 and 0.27 for the number of participants and total assets.

Subsequently, all other works on the occurrence of economies of scale in CSPE started to incorporate the number of participants and total assets as determinants of administrative expenses. For example, Hsin and Mitchell (1997) verified the existence of economies of scale compared to the number of participants (0.74 elasticity) and the total assets (0.49 elasticity) for more than three hundred CSPE from USA's states and municipalities.

Bateman and Mitchell (2004) found coefficient values of 0.4 and 0.5 for the number of participants and total assets of the Australian CSPE. Bikker and De Dreu (2009) estimated coefficient values of 0.59 and 0.09 for the number of participants and total assets of the Dutch CSPE. Malhotra et al. (2009) found a coefficient value of 0.78 for the total assets of US CSPE. Furthermore, Bikker, Steenbeek, and Torracchi (2012) obtained coefficient values of 0.67 for the number of participants and 0.19 for the total assets of CSPE in Australia, Canada, USA, and Holland, concurrently.

In Brazil, Pereira et al. (2013) performed a multiple regression, with data on CSPE administrative expenses for 2010 and 2011. As a result, the investigators found that a 1% increase in the number of participants reflects a 0.05% increase in administrative expenses. In turn, a 1% increase in the total asset variable impacts these same expenses by 0.6%. Pasqualeto *et al.* (2014) performed regressions with panel data for 2010-2012 considering two equations: one using publicly-sponsored entities' data, and the other using privately-sponsored entities' data. In public CSPEs, the natural logarithm for the number of participants showed a coefficient value of 0.078 and, for the total assets, 0.62. Regarding private CSPE, the same coefficients showed the values of 0.004 and 0.52, respectively.

Caetano, Boueri, and Sachsida (2015) developed the most sophisticated models to explain the administrative expenses of Brazilian CSPE. Based on 2010-2011 data, the authors used as explanatory variables: i) the number of participants, ii) total assets, iii) a dummy for private sponsors, iv) a dummy for settlors, v) the number of CSPE plans, vi) the number of CSPE sponsors, and vii) the list of beneficiaries over active participants. In general, all the models developed presented coefficients with signs equal to those expected by the theory.

Finally, Cunha (2018), based on 2010-2014 data, estimated several models to explain the administrative expenses of Brazilian CSPE, seeking to control a possible political effect. The hypothesis adopted in the study was that, in election years, public CSPE would prompt in greater expenses to support candidates aligned with the current government. Although all the models had economies of scale for the main explanatory variables, that is, the total financial assets and the total participants, none of them confirmed the political effect hypothesis for public CSPE.

A common aspect in the works cited above is that they all sought evidence of economies of scale in CSPE by adopting models for the monotonically decreasing average cost curve. To our knowledge, only Bikker (2017) sought to use different models to estimate U-shaped cost functions for Dutch pension funds' administrative expenses during 1992-2009.

Thus, it appears that there is a gap in the literature regarding cost function forms other than the monotonically decreasing for the administrative expenses of CSPE in Brazil and worldwide. Therefore, this

research aimed to investigate whether there is an optimal size for the operation of Brazilian CSPE, based on their administrative expenses. Otherwise stated, we verified whether the Brazilian pension funds would benefit from economies of scale up to a certain point, after which the complexity of the large structures would cause diseconomies of scale, corresponding to estimating the U-shaped cost functions. Therefore, we replicated Bikker's (2017) study, observing Brazilian pension funds peculiarities.

4 Database, Methodology, and Empirical Model

All data was collected from the PREVIC website, the Brazilian industry's supervisory body, using the following instruments: "Disclosure of Administrative Expenses No. 7 and No. 8" study series; CSPE consolidated balance sheets; and individual balance sheets for each of the pension fund plans. Considering that PREVIC released the administrative expense study series only for 2010-2014 and 2017-2018, leaving out 2015 and 2016, we decided to use the most recent period in the study. Also, we adjusted all monetary values based on the 2018 INPC, which is the most used index to adjust post-employment benefits paid by pension funds.

As the data collected combines cross-sectional observations and time series, we adopted the panel data econometrics methodology, which explicitly considers the heterogeneity issue, with the formal capture of the individual differences between the studied units (Gujarati & Porter, 2011).

The database did not have complete information on all CSPE for the investigated period, which meant that the constructed panel data models were unbalanced. However, according to Baltagi (1995), this situation does not compromise the estimates quality. Thus, from a set of 600 observations or 304 CSPE, the final sample comprised 455 observations or 231 CSPE with data for all the variables used in the study.

For estimating the U-shaped optimal cost function of CSPE, we adopted the four equations proposed by Bikker (2017). The first refers to the translog cost function as a second-order Taylor expansion for the total CSPE participants, where economies of scale would be verified for a $\beta_1 < 1$ coefficient, and the average cost curve would have a "U" shape if $\beta_2 > 0$ coefficient. Equation 2 represents the translog cost function for total participants as the main input.

$$lnDP_{it} = \beta_0 + \beta_1(lnPop_{it}) + \beta_2(lnPop_{it} - \overline{lnPop}_{it})^2 + \beta_3 lnQPlan_{it} + \beta_4 Matu_{it} + \beta_5 PerCD_{it} + \beta_6 Fed_{it} + \beta_7 Est_{it} + \beta_8 Mun_{it} + \beta_9 Inst_{it} + \beta_{10} Terc_{it} + \beta_{11} RSB_{it} + \varepsilon_{it} \qquad (2)$$

Where i means CSPE and t is time. The dependent variable $lnDP$ concerns the natural logarithm for social security administrative expenses. The explanatory variables are the natural logarithm for the total number of participants $(lnPop)$, and the natural logarithm for the total participants centered on the square mean $(lnPop - \overline{lnPop})^2$. The other control variables are the natural logarithm for the number of benefit plans $lnQPlan$; the maturity of CSPE $Matu$; the percentage of DC plans compared to the total plans $PerCD$; dummy federal CSPE Fed; dummy state CSPE Est; municipal CSPE dummies Mun; dummy CSPE created by settlors $Inst$; the percentage of expenses with third-party services over total expenses (outsourcing) $Terc$; and dummy CSPE located in Rio de Janeiro, São Paulo, or DF RSB.

We expected a positive value lower than the unit for the natural logarithm coefficient of the number of plans, indicating that a new plan's offer increases pension expenses less than on a *pro-rata* basis (Caetano et al., 2015). In turn, concerning the CSPE maturity coefficient, which is given by the quotient between benefits to be granted and benefits granted, we expected a positive signal, understanding that the more people enjoy benefits in CSPE, the greater will be the social security expenses with attendance, communication, and actuarial and legal demands.

As for the percentage of DC plans managed by CSPE, we believed that their coefficient should be negative and statistically significant. This hypothesis stemmed from the fact that the DC plans are risk-free, which reduces expenses with actuarial and legal services as the number of these plans increases in the funds' portfolios compared to the DB and VC plans.

About the type of sponsorship of CSPE, we adopted private sponsorship as a base category. Thus, according to Caetano et al. (2015) and Cunha (2018), we expected that public (federal, state, and municipal) CSPEs would have higher administrative expenses. However, we expected that the settlor-maintained CSPE would have lower administrative expenses than the private CSPE, mainly because the former do not rely on sponsors and are maintained exclusively by their participants and their investments, requiring a high level of administrative and financial discipline to be profitable.

Considering the outsourcing variable coefficient, we expected a negative sign, showing that the greater the expense exchange with the maintenance of the own staff, due to higher expenses with third-party services, the greater the potential for decreasing administrative expenses (Bikker & De Dreu, 2009; Cunha, 2018). Finally, according to Cunha (2018), we should expect a positive coefficient for the dummy CSPE located in Rio de Janeiro, São Paulo, or DF, as these metropolises have higher living costs compared to other Brazilian locations.

As recommended by Bikker (2017), we tested three additional alternatives for the "U" cost function: 1) the unrestricted Laurent function (ULF), which is similar to translog but with two additional terms for the total

number of participants, that is, $1/(lnPop)$ and $1/(lnPop)^2$, where, according to Shaffer (1998), for the "U" shape to remain, the coefficients of these two new variables must be positive and close in magnitude of β_2; 2) a simplified version of ULF, with only $1/(lnPop)$ as an additional term; and 3) the Cobb-Douglas cost function, which changes the coefficient β_2 of the original translog equation, that is, $(lnPop_{it} - \overline{lnPop_{it}})^2$, to $1/Pop$ (one divided by the total population). Unlike the others, this last equation depicts the "U" shape if $\beta_1 > \beta_2$. However, if $\beta_1 > 1\ e\ \beta_2 > 0$, the average cost curve starts to behave in monotonic decline. Lastly, if $\beta_1 < 1$, the average cost curve has an "L" shape.

According to Bikker (2017), the rule of thumb for choosing the best among the four models consists of two stages. In the first, we should evaluate the variance inflation factor (VIF) to identify occasional multicollinearity in the model. If there is no such problem, that is, VIF <10, we should proceed to the second stage, which comprises the analysis of the Akaike criterion. For the latter, the lower the value obtained, the better the model.

The second estimate for the U-shaped optimal cost of CSPE concerns the translog cost function as a second-order Taylor expansion with the total financial assets as input, with economies of scale being identified for the coefficient $\beta_1 < 1$, and the average U-shaped cost curve if the coefficient of $\beta_2 > 0$. Equation 3 represents the translog cost function for total financial assets as the main input.

$$lnDI_{it} = \beta_0 + \beta_1(lnAtivo_{it}) + \beta_2(lnAtivo_{it} - \overline{lnAtivo_{it}})^2 + \beta_3 lnQPlan_{it} + \beta_4 Solv_{it} + \beta_5 PerCD_{it} + \beta_6 Fed_{it} + \beta_7 Est_{it} + \beta_8 Mun_{it} + \beta_9 Inst_{it} + \beta_{10} Terc_{it} + \beta_{11} RSB_{it} + \varepsilon_{it} \qquad (3)$$

Where: i means CSPE and t is time. The dependent variable *lnDI* refers to the natural logarithm for administrative investment expenses. The explanatory variables are the natural logarithm for the total financial assets ($lnAtivo$) and the natural logarithm for total financial assets centered on the square mean $(lnAtivo - \overline{lnAtivo})^2$. The other control variables are the same as in Equation 2, except for $Matu$, which we replaced with the solvency variable $Solv$.

In Equation 3, the expectation regarding most coefficients' signs was the same as in Equation 2. The solvency variable is the only one that should be explained. Given the solvency variable is formed by the quotient of the mathematical provisions for the CSPE coverage equity, we expected a negative sign, indicating that the more solvent is the CSPE, the lower their investment expenses, indicating efficient administrative resource management.

Additionally, we estimated three other alternatives for the cost function of total financial assets: 1) ULF, with additional terms to the translog function $1/(lnAtivo)$ and $1/(lnAtivo)^2$; 2) the simplified version of ULF, with only $1/(lnAtivo)$ as an additional term; and 3) the Cobb-Douglas cost function, which replaces the term $(lnAtivo - \overline{lnAtivo})^2$ with $1/Ativo$ (one divided by the total financial assets). Figure 2 summarizes all the explanatory variables used in the equations, their expected signs, and the empirical reference.

Variable	Expected Sign	Empirical Reference
$(lnPop)$	+	Caswell (1976); Mitchell and Andrews (1981); Hsin and Mitchell (1997); Bateman and Mitchell (2004); Malhotra et al. (2009); Bikker et al. (2012); Pasqualeto *et al.* (2014); Caetano et al. (2015); and Cunha (2018)
$(lnPop_{it} - \overline{lnPop_{it}})^2$	+	Bikker (2017)
$1/(lnPop)$	+	Bikker (2017)
$1/(lnPop)^2$	+	Bikker (2017)
$1/(Pop)$	+	Bikker (2017)
$(lnAtivo)$	+	Mitchell and Andrews (1981); Hsin and Mitchell (1997); Bateman and Mitchell (2004); Malhotra et al. (2009); Bikker et al. (2012); Pasqualeto *et al.* (2014); Caetano et al. (2015); and Cunha (2018)
$(lnAtivo - \overline{lnAtivo})^2$	+	Bikker (2017)
$1/(lnAtivo)$	+	Bikker (2017)
$1/(lnAtivo)^2$	+	Bikker (2017)
$1/Ativo$	+	Bikker (2017)
$lnQPlan$	+	Pasqualeto *et al.* (2014); Caetano et al. (2015); and Cunha (2018)
$Matu$	+	Teixeira, Santos, and Macedo (2020)
$PerCD$	-	Bikker and De Dreu (2009); Teixeira et al. (2020)
Fed	+	Bikker et al. (2012); Cunha (2018)
Est	+	Bikker et al. (2012); Cunha (2018)
Mun	+	Bikker et al. (2012)
$Inst$	-	Caetano et al. (2015); and Cunha (2018)
$Terc$	-	Bateman and Mitchell (2004); Bikker and De Dreu (2009); Bikker (2017); Cunha (2018)
RSB	+	Cunha (2018)
$Solv$	-	Teixeira et al. (2020)

Figure 2: Summary Explanatory Variables Used
Source: Elaborated by the authors.

5 Results Analysis

We estimated Equation 2 and its derivations to investigate whether there is an optimal size for Brazilian CSPE to minimize their administrative expenses with social security management. Otherwise stated, we sought to verify whether such expenses have a U-shaped behavior when the total number of participants linked to these entities increases. Table 2 summarizes the results.

Table 2:
Estimated Models for Social Security Administrative Expenses

Variable	Translog	Unrestricted Laurent Function (ULF)	ULF Simplified Version	Cobb-Douglas Function
LnPop	0.4366***	0.7964***	0.4422***	0.4260***
LnPop² (mean deviation)	0.0462***	-0.0095	0.0431***	-
1/(Pop)	-	-	-	6.3752***
1/(LnPop)	-	26.1519***	0.3112	-
1/(LnPop)²	-	-13.8307***	-	-
LnQPlan	0.2799***	0.2777***	0.2814***	0.3219***
Maturity	0.0012	0.0014	0.0012	0.0016
DC Plan Percentage	-0.1434	-0.1666	-0.1442	-0.1744*
Federal	0.7945***	0.8077***	0.7971***	0.8348***
State	0.2942***	0.2972***	0.2922***	0.2822**
Municipal	-0.6175*	-0.5601	-0.6133*	-0.5903
Settlor	-0.4897***	-0.4719***	-0.4870***	-0.4311**
Outsourcing	-1.1206***	-1.1546***	-1.1203***	-1.1348***
CSPE in RJ, SP, or DF	0.1812**	0.1853**	0.1812**	0.1934**
Constant	11.1762***	5.2810**	11.0952***	11.3223***
No. of Observations	455	455	455	455
F Statistics	83.61	72.17	76.50	80.06
Adjusted R² (%)	66.68	67.08	66.62	65.70
VIF (mean)	1.36	51.61	1.69	1.35
Akaike criteria	992.12	988.56	993.99	1005.33
Swekness-Kurtosis (χ²)	2.57	1.64	2.31	5.20
Breusch-Pagan (χ²)	0.10	0.00	0.12	0.84
First Derivative	0.437 + 2*0.046*(LnPop - mean LnPop)	0.796 + 2*-0.0095*(LnPop -mean LnPop) − 26.152/(LnPop)² +2*13.831/(LnPop)³	0.442 + 2*0.043*(lnPop - mean LnPop) − 0.311/(LnPop)²	0.426 − 6.375/Pop
Optimal Size (participants)	2,094,243	1,031,463,723,342	3,109,586	No Optimum
Elasticity Cost	0.437	0.476	0.438	0.425

***significant at 1%; **significant at 5%; *significant at 10%.
Source: Elaborated by the authors.

At first glance, all the estimated models presented normal distribution and constant variance in the residues (homoscedasticity). Moreover, the F statistic revealed that the combined independent variables are significant, with the adjusted R² showing an explanatory power of at least 65.7%.

To choose the best model, we used the criterion proposed by Bikker (2017). Thus, since the ULF model had an average VIF greater than 10, we discarded it in the first evaluation stage because it presented the multicollinearity problem. Subsequently, we obtained the lowest value for the Akaike criterion using the translog model, which was the best to explain the CSPE social security management's administrative expenses.

As verifiable through the translog model, the Brazilian CSPE market has an optimal number of participants that minimizes social security management expenses, given the coefficients $\beta_1 < 1$ and $\beta_2 > 0$ presented the expected magnitudes and signs, both significant at 1%.

The economies of scale captured by the coefficient β_1 were greater than 56% (1 - 0.4366). When applying the first derivative in the translog function concerning the population and equaling to one, we obtained the optimal number of participants in the Brazilian CSPE, which was 2,094,243 people for the period 2017-2018. This result suggests that the implementation of more entry barriers and CSPE concentration would benefit their participants in terms of cost reduction, particularly considering that the largest Brazilian pension fund in 2018 had approximately just over 195 thousand people.

The coefficient of the natural logarithm of the number of plans was positive and significant, as found by Cunha (2018), indicating that a 1% increase in plans' offer causes a 0.28% increase in social security administrative expenses, which strengthens economies of scale.

Concerning the CSPE dummies with federal and state public sponsorship, we observed positive and significant coefficients, as expected. Otherwise stated, this result corroborates that privately sponsored pension funds tend to be more efficient than these two types of public funds. However, the opposite effect occurred with public municipal CSPE and the settlor-founded CSPE, showing that detailing funds' sponsorship type is important to avoid generating spurious conclusions. Pereira et al. (2013) and Caetano et al. (2015), when simultaneously analyzing publicly sponsored CSPE *versus* privately sponsored CSPE, concluded that the latter were more economical than the former, which is not necessarily true, as public municipal CSPE proved to be more efficient than private CSPE.

The coefficients of the outsourcing and location variables were also significant and kept with the expected signs. While the first one was negative, as in Bikker and De Dreu (2009) and Cunha (2018), confirming that higher expenses with third-party services lead to lower administrative expenses, the second one was positive, showing that living cost in large cities of Rio de Janeiro, São Paulo, and DF contributes to increasing the expenses of funds based in these cities.Interestingly, despite the maturity coefficients and percentage of DC plans showing the expected signs, none of them were significant to explain the CSPE's social security administrative expenses.

The investment administrative expense models initially revealed the problem of non-normality and heteroscedasticity in residues, requiring the exclusion of 71 observations with atypical behavior in the first three models (translog, ULF, and ULF simplified version) and 72 in the last one (Cobb-Douglas). We established normality in all models after these eliminations, with heteroscedasticity also used for the translog function. For the other models, we accommodated the heteroscedasticity problem by adjusting robust Huber-White standard errors. Table 3 summarizes the results. The adjusted R^2 was higher than 84.9% in all models, and the F statistic rejected the null hypothesis that all coefficients are equal to zero for the explanatory variables.

Table 3:
Estimated Models for Investment Administrative Expenses

Variable	Translog	Unrestricted Laurent Function (ULF)	ULF Simplified Version	Cobb-Douglas Function
LnAtivo	0.5820***	7.7923	2.1433**	0.6401***
LnAtivo² (mean deviation)	0.0259***	-0.1839	-0.0470	-
1/(Ativo)	-	-	-	1.29E+07***
1/(LnAtivo)	-	5,302.94	638.7343*	-
1/(LnAtivo)²	-	-23,460.03	-	-
LnQPlan	0.2831***	0.2665***	0.2696***	0.2832***
Solvency	-0.0674	-0.0641	-0.0642	-0.0661
DC Plan Percentage	-0.1597*	-0.1907*	-0.1955**	-0.2204**
Federal	0.6004***	0.6071***	0.6073***	0.6356***
State	0.2480***	0.2862***	0.2878***	0.2621***
Municipal	-0.2554	-0.1903	-0.1868	-0.1806
Settlor	-0.2966**	-0.2785	-0.2645	-0.2251
Outsourcing	-0.2761**	-0.2167*	-0.2187*	-0.2344*
CSPE in RJ, SP, or DF	0.1717***	0.1708**	0.1735**	0.1819***
Constant	2.2088***	-348.48	-60.9765	1.0122*
No. of Observations	384	384	384	383
F Statistics	197.41	290.85	245.21	195.71
Adjusted R² (%)	84.94	85.57	85.57	85.21
VIF (mean)	1.36	3.02E+05	589.43	1.46
Akaike criteria	620.01	620.68	620.86	622.22
Swekness-Kurtosis (χ²)	1.90	1.91	1.61	0.63
Breusch-Pagan (χ²)	5.13	7.94	8.43	7.49
First Derivative	0.528 + 2*0.026*(LnAtivo - mean LnAtivo)	7.792 + 2* -0.184*(LnAtivo -mean LnAtivo) - 5,303/(LnAtivo)² + 23,460/(LnAtivo)³	2.143 + 2* -0.047*(LnAtivo - mean LnAtivo) - 639/(LnAtivo)²	0.6401 – 1.29E+07/Ativo
Optimal Size (Total Assets)	BRL 2,767 bi	BRL 88,519,565 bi	BRL 152,777 bi	No Optimum
Elasticity Cost	0.528	-2.048	0.633	0.625

***significant at 1%; **significant at 5%; *significant at 10%.

Note: As the null hypothesis of homoscedasticity was rejected at 1% significance for the models derived from the ULF functions, simplified version ULF, and Cobb-Douglas, its results were already presented considering the adjustment of robust Huber-White standard errors.

Source: Elaborated by the authors.

As the translog function presented a VIF statistic <10 associated with the lowest value for the Akaike criterion among all models, we can once more argue that this is the most appropriate model according to the

criteria proposed by Bikker (2017) to explain administrative expenses with investments in the Brazilian closed supplementary pension market.

The coefficients $\beta_1 < 1$ and $\beta_2 > 0$ for the total assets and its quadratic version presented the expected magnitudes and signs, both of which were significant at 1%, allowing us to conclude that an optimal amount of financial assets that minimizes CSPE investment expenses does exist. While the coefficient β_1 of the natural logarithm of total assets showed economies of scale in an order of 41.80% (1 - 0.5820), the calculation of the first derivative for administrative expenses concerning financial assets revealed that Brazilian pension funds would reach the minimum "U" curve with approximately BRL 2,767 billion. In this regard, it is once more possible to verify that Brazilian CSPE are far from this mark since the largest Brazilian pension fund had in its portfolio an amount of BRL 205 billion in assets in 2018.

Regarding the solvency coefficient, which is a financial variable, it was possible to infer that its sign was negative, as expected. However, this variable did not show statistical significance to explain the administrative expenses with investments.

In turn, the coefficient of the percentage variable of DC plans was negative and significant at 10%, showing that entities with more DC plans in their portfolios have lower administrative expenses with investments. Therefore, the management of DC plans is cheaper than DB and VC plans, which have actuarial risks and involve high expenses with actuarial consultancy to monitor and restructure deficits, as found by Teixeira et al. (2020).

6 Final Considerations

This research aimed to investigate whether there is an optimal size for the operation of Brazilian CSPE, based on their administrative expenses. Otherwise stated, we intended to verify whether the Brazilian pension funds would benefit from economies of scale up to a certain point, after which the complexity of the large structures would cause diseconomies of scale.

For this purpose, we used the classical theory of industrial organization as background, focusing on barriers to the entry of new businesses, mainly because the existing economies of scale provide great advantages to incumbent CSPE in terms of minimizing costs, directly benefiting their participants.

The results showed that the Brazilian closed private pension market has an optimal operation point, minimizing social security and investment administrative expenses. Considering the social security administrative expenses, we found that the ideal number of CSPE participants would be around 2.1 million. Conversely, the target volume of financial assets would be around BRL 2.8 trillion for administrative expenses with investments.

Considering that in 2018 the largest Brazilian CSPE had 195 thousand participants and BRL 205 billion in assets, this entity could grow over ten-fold before reaching its optimal point. Consequently, the concentration of the pension funds' market in a few CSPE would bring enormous benefits to its active and inactive participants in terms of cost, warranting CNPC's actions to restrict the entry of new funds, as already stated in Resolution no. 35 from 2019, Art. VI, item III, which conditions the creation of new CSPE to a minimum number of 10,000 participants.

In this regard, Bikker (2017) stated that the merging of smaller funds would be beneficial for the market since the scale earnings captured by a larger structure would be passed on to its participants as an expansion of social security savings granting better post-employment benefits.

For future work, we propose that the calculation of the optimal size for Brazilian pension funds be carried out according to the classification of the total financial assets in five different groups (A, B, C, D, and E), according to the one presented by PREVIC in its "study series," which deal with administrative expenses in CSPE. Thus, it would be possible to analyze whether economies of scale differ significantly between groups, where the smallest funds are expected to benefit from greater economies of scale than the larger ones.

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Conception and elaboration of the manuscript: R. F. A. P. Teixeira, A. Rodrigues
Data collection: R. F. A. P. Teixeira
Data analysis: R. F. A. P. Teixeira
Discussion of results: R. F. A. P. Teixeira
Review and approval: R. F. A. P. Teixeira, A. Rodrigues

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The entire data set that supports the results of this study was published in the article itself.

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[i] In 2017, there were 304 CSPE, and, in 2018, that number dropped to 296 (PREVIC, 2020c). However, in 2017, only 225 CSPE provided the necessary data for the calculation of all statistics; the same occurred in 2018, when only 230 CSPE provided data

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