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OPERATIONAL EFFICIENCY AND SUSTAINABILITY COMPONENTS: A CURVE AND SURFACE FITTING ANALYSIS OF THE THREE LARGEST BANKS IN BRAZIL

COMPONENTES DE EFICIÊNCIA OPERACIONAL E SUSTENTABILIDADE: UMA ANÁLISE POR AJUSTES DE CURVA E DE SUPERFÍCIE DOS TRÊS MAIORES BANCOS NO BRASIL

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Abstract: *This research aims to analyze if the three largest banks in Brazil (Itaú Unibanco, Bradesco and Santander) were operating optimally between December 2022 and December 2023, considering the four components of the Operational Efficiency Index (OEI) and the Corporate Sustainability Index (ISE). For this purpose, future projections of the OEI components were made by polynomial curves adjustments for the average trend and trigonometric adjustments for data fluctuations. The optimal values between efficiency and sustainability were calculated for each bank and component, based on the adjustment of a Cobb-Douglas Function, that represents this relation. For the sample and period analyzed, the study concludes that Santander operated close to the optimal ratio on more components (Financial Intermediation Result and Service Revenues), followed by Bradesco that operated close to this ratio on Operating Expenses and Itaú Unibanco did not operate close to the optimal ratio on any operational efficiency component.*

Keywords*: Banks; Efficiency; Sustainability; Forecasts; Cobb-Douglas Function.*

Resumo: Esta pesquisa busca analisar se os três maiores bancos do Brasil (Itaú Unibanco, Bradesco e Santander) operaram de maneira ótima entre dezembro/2022 e dezembro/2023, considerando os quatro componentes do Índice de Eficiência Operacional (IEO) e o Índice de Sustentabilidade Empresarial (ISE). Realizaram-se projeções futuras dos componentes do IEO por meio de ajustes de curva polinomiais para a tendência média e ajustes trigonométricos para flutuações de dados. Calcularam-se os valores ótimos entre eficiência e sustentabilidade para cada banco e componente, a partir do ajuste de uma função de Cobb-Douglas, que representa esta relação. Para a amostra e período analisados, o estudo conclui que o Santander foi o banco que operou próximo da relação ótima para mais componentes (Resultado da Intermediação Financeira e Receita de Serviços), seguido do Bradesco, operando próximo desta relação para Despesas de Pessoal, enquanto o Itaú não operou próximo da relação ótima para nenhum componente de eficiência operacional.

Palavras-chave: Bancos; Eficiência; Sustentabilidade; Projeções; Função de Cobb-Douglas.

1 INTRODUCTION

1.1 Sustainability

Competitiveness in corporate environment influences innovation and the evolution of the organizational processes, in which sustainability is one of the means that allows the improvement of the business model. Despite being more costly in a short term, according to Nicoletti Junior et al. (2022), the sustainable approach can optimize resources and the operational performance in an efficient way, from the cost reduction, increasing products and services quality and promoting innovation, contributing to enhancing corporate competitiveness.

The generation of value through business model includes different perspectives and stakeholders' profiles, aiming a common direction towards sustainability (Attanasio et al., 2022). Consequently, the stakeholders have been searching for investments in sustainable organizations, and the adoption of companies' valuation methods is essential.

According to the Stakeholders Theory, the unification of the investors interests with the society is necessary, aiming the maximization of the organizations value in the long term (Guimarães; Peixoto; Carvalho, 2017). It should be noted the importance of understanding and creating common interests among stakeholders (Hadi; Hamdani; Roziqin, 2023) and, consequently, generating value for the companies in a sustainable manner.

Market forecasts are essential for stakeholders to evaluate and monitor their investments, which can be calculated using reported information of organizational performance. It is worth pointing out that a recent practice in Brazil is the voluntary disclosure of a report containing future

expectations of companies' results, known as guidance, which aims to reduce information asymmetry (Macedo Neto et al., 2014; Silva; Lamounier; Andrade, 2023).

Given this context, being sustainable is no longer a competitive advantage for companies. It is a requirement in the capital markets, as accountability and disclosure have become important instruments to evaluate the extent to which firms are committed to the ESG (Environmental, Social and Corporate Governance) agenda. Previous studies, such as Bartov et al. (2021) and Krueger et al. (2024), show that this commitment reduces operational risks and volatility, which makes firms more attractive to stakeholders. Therefore, it aims business continuity and space in a competitive market and has become increasingly prominent on the society's agenda. The Brazilian Stock Exchange (B3) created the Corporate Sustainability Index (ISE) in 2005, which consists in an average stock performance index of selected companies and can influence stakeholders' decision-making and the adoption of ESG practices by organizations (B3, 2023a).

The Corporate Sustainability Index can be used to indicate accounting information quality and disclosure, in which the objective is to present the importance of the relation between corporate sustainability and economic-financial performance (Silva; Santos; Alcoforado, 2021). Therefore, the participation in a sustainability index can affect companies' performance and increase their visibility with investors (Guimarães; Rover; Ferreira, 2018).

Additionally, ISE measures the stock return of the companies that compose it and has been adopted by organizations as a planning tool for sustainable initiatives, also has a potential to become a guide in the establishment of standards and to access corporate information (Rufino et al., 2014). Thus, this index supports investments decision-making and encourage the adoption of ESG practices, which sustains business continuity (B3, 2023b).

For this matter, sustainability can influence companies' performance, such as financial institutions. According to Belasri; Gomes; Pijourlet (2020), the evolution of corporate social responsibility can influence financial performance and improve organizations' performance and, consequently, demonstrate to investors that sustainable practices impact this sector operations.

1.2 Efficiency

Despite ESG being extremely relevant for the market, measuring real improvements in companies' sustainability practices still remains difficult. Thus, many securities markets have created their own index, such as the Dow Jones Sustainability Index (DJSI) in the United States (U.S.), the Euro STOXX in Europe, the ISE in Brazil, among others, each with its own methodology and focus (e.g. Environment, Social and Governance). However, banks operate with indexes in a different way. Due to their complex operational context, they typically emphasize the governance perspective within these indexes. Furthermore, it is important to analyse the banking industry, mainly excluded in research due to its characteristics and regulation, particularly in an emerging market like Brazil. Thus, this study adopts the ISE as the sustainability index. In addition, banks rely on the Operational Efficiency Index (OEI), a key metric used to evaluate their operational performance.

While ESG indexes measure sustainability-related factors, the OEI focuses on the efficiency and effectiveness of banks' operations, especially in areas where governance plays a key role, which is fundamental for both investors and managers decision-making. Therefore, analysing of the relationship between the OEI and an ESG index (the ISE in Brazil in this study) provides valuable insights for investors and managers, offering an evaluation of how governance practices influence the operations of a bank.

Efficiency measurement is fundamental for banks due to market competitivity, justifying the importance of analysing this sector performance, according to Mendonça; Souza; Campos (2016). Thus, the Operational Efficiency

Index is one of the indicators used in these organizations, as it demonstrates their ability to maintain their operations.

The OEI is widely used in banks evaluation, due to the relation between operational expenses and financial intermediation incomes, in which the lower the results, the smaller the structure necessary for operational continuity (Assaf Neto, 2000), and can influence the stakeholders' investments evaluation. This index is calculated by dividing the sum of Personnel and Administrative Expenses by the sum of Financial Intermediation Result and Services Revenues (Mendonça; Souza; Campos, 2016).

1.3 Objectives

The goal of this research was to analyse in an optimal way each component of the Operational Efficiency Index (OEI), which are Personnel Expenses, Administrative Expenses, Financial Intermediation Result and Services Incomes, by calculating the optimal value between efficiency and sustainability, using data of the three largest Brazilian banks (Itaú Unibanco, Bradesco e Santander) for the sample of this study, due to their representativeness in Brazil.

For this purpose, future projections of the OEI components were made by polynomial curves adjustments for the average trend and trigonometric adjustments for data fluctuations. The dependency relation was made between operational efficiency components, OEI and ISE, via multivariate adjustments of Cobb-Douglas type functions, with the data properly described.

Subsequently, the optimal values that maximize or minimize each component were determined, defining an optimal relation between OEI and ISE within the domain where the Cobb-Douglas type function is defined.

Finally, a comparison between a reference value and the optimal relation results was made, based on Confidence Intervals with 95% confidence under t-student distributions, to verify if the banks of the sample with data between the fourth quarter of 2022 to the second quarter of 2023 and their future forecasts were operating optimally.

However, within the proposed methodology, it was possible to verify that Santander operated close to the optimal relation on more operational efficiency components (Financial Intermediation Result and Services Incomes), Bradesco operated close to this relation on one of the components (Personnel Expenses), and Itaú did not operate close to this relation on any of the four operational efficiency components, considering the study period.

The practical contribution of this study is to present the construction of a market forecast model, aiming to support stakeholders' investments evaluation and decision-making, based on the Cobb-Douglas function, establishing the optimal value between efficiency and sustainability for each OEI. Additionally, it has academical contributions by using mathematical models (polynomial curve adjustments, trigonometric adjustments for data oscillations and Cobb-Douglas function), which is not much used in Applied Social Sciences. It should be noted that, to the best of the authors' knowledge, this is the first study to compare the Operational Efficiency Index and the Corporate Sustainability Index for the three largest banks in Brazil, which is an emerging market, while also adopting this methodology.

The study is divided into seven sections: this introduction, which presents the research contextualization; efficiency and sustainability in banks, which mentions about the OEI, ISE and relate efficiency and sustainability with governance; the mathematical models, presenting the adopted method; the data and results obtained; the conclusions; the acknowledgments; and the references.

2 EFFICIENCY AND SUSTAINABILITY IN BANKS

The Operational Efficiency Index (OEI) demonstrates the organization's capacity to maintain their operations, in which the lower the index, the smaller the structure necessary for its maintenance.

Therefore, the index can be considered an indicative of business continuity, which contains

ESG practices.

Additionally, governance constitutes a fundamental pillar of corporate sustainability, as it includes mechanisms of accountability, transparency, fairness, and regulatory compliance that support the long-term continuity of organizations. From this perspective, operational efficiency can also serve as an indicator of governance quality, as efficient resource allocation and cost management are typically associated with stronger internal controls and managerial monitoring.

Sustainability can be applied as a proxy of corporate governance in empirical studies, as it can indicate business continuity, such as the OEI. Thus, the governance of banks is influenced by their operational efficiency (Korontai; Fonseca, 2020).

Furthermore, this index presents the influence of operational expenses (Personnel and Administrative Expenses), financial intermediation results and services income, so the lower the index, the higher is the company's performance. Therefore, as previously mentioned on Section 1, the OEI is calculated as presented on Equation 1, according to the literature:

$$\frac{Personnel\ Expenses + Administrative\ Expenses}{Financial\ Intermediation\ Result + Services\ Incomes} \quad (1)$$

Based on Fethi; Pasiouras (2010), there are two opposite perspectives in studies regarding banks, which are: the efficiency, associated with financial intermediation influences economic growth; and bank insolvency, that can generate systemic crisis impacting on the economy in general. Thus, this institutions importance is observed, which can influence scenarios of economic growth or recession, as well as the Financial Intermediation Result (one of the four components of the Operational Efficiency Index), particularly in emerging markets, such as Brazil, which is the focus of this study due to its informational environment, informational asymmetry and market volatility.

Expenses and income analysis is another way to verify bank efficiency (Fethi; Pasiouras, 2010), which also supports investors' decision-making. Equation 1 shows the expenses and incomes that compose the OEI, according to the literature. It should be mentioned that these components are fundamental for companies to operate.

Therefore, it is important to adopt Personnel Expenses, Administrative Expenses, Financial Intermediation Result and Services Incomes to calculate the index, as they are essential for business continuity, the economy and the society. Thus, following the literature and given the importance of these components for a bank's business continuity, this study considers them in the analysis of the relationship between the OEI and ISE.

It should be noted that, among the three banks in this research sample (e.g. Itaú Unibanco, Bradesco and Santander), which are the largest banks in Brazil, only Santander disclosed how they calculated the OEI to the market for the period of data collection (2020 until 2023), as presented on Equation 2:

$$\frac{General\ Expenses}{\begin{array}{c}Gross\ Financial\ Margin + Income\ from\ Services\ and\ Banking\ Fees + \\ Tax\ Expenses + Other\ Operational\ Incomes\ and\ Expenses + Results \\ from\ Participation\ in\ Affiliates\ and\ Subsidiaries\end{array}} \quad (2)$$

As mentioned above, sustainability is often used as a proxy of corporate governance in many studies, because it can be seen as a parameter of business continuity, similar to the Operational Efficiency Index. Therefore, this research demonstrates the importance of analysing the relationship between the OEI and the Corporate Sustainability Index (ISE), as both can indicate a company's business continuity.

Additionally, the global scenario has turned its attention to sustainability and to investors, generating incentives for the creation of sustainability indexes, aiming to disclose companies' sustainable practices and to relate them to the organizations' performance (Dağistanli, 2023). Thus, these indexes are fundamental for both investors' decision-making and for guiding managers strategic choices.

The ISE was created by B3 in 2005 and indicates the average stock performance of selected companies as they compromise with corporate sustainability (B3, 2023a). Still, according to B3, this index supports stakeholders' investments decision-making, and it is a reference for investments in companies with sustainable practices.

The ISE shows the result of a theorical stock portfolio correspondent to the listed companies in B3 that are not BDRs[1] (Brazilian Depositary Receipt), in judicial or extrajudicial recovery, under a special regime of temporary administrating, intervention or negotiated in other peculiar situations (B3, 2023c).

B3 sends a questionary to 200 organizations with the most negotiated stocks to define the companies that will be in ISE, all must provide supporting documentation, to select up to 40 companies of different sectors (Silva; Santos; Alcoforado, 2021). This questionary has the following dimensions: Human Capital, Corporate Governance and Higher Administration, Business Model and Innovation, Social Capital, and Environment (B3, 2023d). B3 mentions an additional dimension, Climate Change, in ISE guidelines, however, there are no questions about this in the questionary, as it is evaluated by the CDP Score - Climate Change (CDP[2] index).

Besides being amongst the 200 companies with the most negotiated stocks in B3 during the last three portfolios period, the organization needs to have stock negotiated in at least 50% of trading during that period, must not be classified as a penny stock[3] and satisfy the sustainability criteria, according to B3.

Such sustainability criteria consists in having the ISE score equal or higher than a minimum score to select the companies that will compose the index portfolio, the score per dimension of the questionary equal or higher than 0,01 point, a qualitative score of at least 70 p.p., CDP Score equal or higher than C, reputational risk index lower or equal to 50, and positive answers in the questionary for topics considered as a requirement of the company's sector (B3, 2023d).

The study of Silva; Santos; Alcoforado (2021) verifies the influence of the participation in the Corporate Sustainability Index on many financial indicators of banks participating and non-participating in the ISE, considering the period between 2010 and 2019. One of the indexes adopted by the authors was the OEI, where they observed a lower variability around the mean for companies that compose ISE, considering the sample and period of the study, and consequently, with a higher operational efficiency. In addition, banks participating in the ISE may not have the best financial results in the short-term period but tend to generate better results in the long-term, which suggests that these banks can be seen as opportunities for investors (Silva; Santos; Alcoforado, 2021), highlighting the importance of a sustainability index in the capital markets.

Footnotes:

[1] Certificates of securities deposit traded on B3 that represent the stocks issued abroad.

[2] CDP is an international company that analyses organizations by a climate perspective.

[3] Stocks negotiated for less than R$ 1 in the Stock Exchange.

Belasri; Gomes; Pijourlet (2020) observe that corporate social responsibility has a positive impact on the efficiency of 184 banks, located in 41 countries, for the period between 2009 and 2015, adopting the Data Envelopment Analysis (DEA). In addition, it demonstrates that this responsibility evolution can increase bank efficiency, generate financial benefits and, consequently, a better use of resources, for the sample and period analysed, justifying the importance of analysing both sustainability and efficiency.

Montenegro et al. (2020) verify the effect of information technology on production factors from the 18 largest Brazilian banks between 2001 and 2016, by subprime crisis perspective, using the Cobb-Douglas function to capture it. Among the results, the authors highlight that innovations that aim to increase earnings are essential to enhance banking capacity and efficiency, especially in times of increased preference for liquidity. Therefore, many factors influence bank efficiency, which can be measured by the OEI, including information technology (Montenegro ET AL., 2020), corporate social responsibility (Belasri; Gomes; Pijourlet, 2020), and a sustainability index, as this study aims to demonstrate.

3 MATHEMATICAL METHODS

The application of mathematical methods in the Applied Social Sciences has grown significantly in quantitative research. Thus, mathematical modelling provides a systematic way to evaluate the capital markets, such as market dynamics (e.g. forecasts), indexes (e.g. Operational Efficiency Index and Corporate Sustainability Index), and business choices (e.g. firms' performance).

Therefore, given the context presented in sections 1 and 2, the quarter data of the OEI components (Personnel Expenses, Administrative Expenses, Financial Intermediation Result and Services Incomes, according to the literature) was selected from the financial reports and the index itself, published on the Investors Relations site of Itaú Unibanco (2023), Bradesco (2023) and Santander (2023), which are the three largest Brazilian banks. The period between the first quarter of 2020 and the second quarter of 2023 was considered, aiming to obtain the best forecasts based on the historical data.

Furthermore, the data regarding the participation of these financial institutions in the ISE portfolio was collected daily (working days) from May 2023 to September 2023, as B3 does not provide the historical data of the composition of this index portfolio.

It was observed that the data has a parabolic trend with oscillation on the constructed data dispersion plot. Therefore, it was chosen to use quadratic and data oscillation adjustments, which consist in trigonometric functions (sines e cosines) with many frequencies (periodic functions). It was also adopted the GMRES method (Generalized Minimal Residual Method), as it is a robust method that deals with situations in which the condition numbers are higher, seeking for a better performance on solving the linear system (Saad; Schultz, 1986).

Therefore, a monthly database was elaborated considering the period between December 2022 and December 2023 to obtain the same time basis for the Cobb-Douglas function, using Octave® software. This database contained the estimates of the participation in the ISE portfolio, OEI and its components.

Subsequently, the Cobb-Douglas function was applied to each component, OEI and ISE of Itaú, Bradesco and Santander. It was also used to calculate the optimal values, solving the optimization problem based on minimums and maximums of real functions in closed intervals, and the optimal relations. These relations were obtained from the division of the Operational Efficiency Index and the Corporate Sustainability Index associated with an optimal value.

The Cobb-Douglas function is adopted to calculate production, considering the amount of labour and invested capital (Ferreira; Silva, 2015), representing the relation between them over a certain period, which can be expressed as demonstrated in Equation 3 in the next page. It can also be used for econometric estimates, enabling a behaviour identification from a

historical database (Martins et al., 2012).

$$P = bL^{\alpha}K^{\beta}, (3)$$

P is the total productivity, L the labour and K the invested capital.

In this research context, it was considered a dependent function of OEI and ISE variables for each Operational Efficiency Index component, for example, the Personnel Expenses component as:

$$Personnel\ (OEI, ISE) = b(OEI)^{\alpha} ISE^{\beta}, (4)$$

The constants α, β and b are obtained via multivariate functions adjustments using the least squares method (Ruggiero; Lopes, 1996). The linear systems associated with the adjustments were solved adopting the GMRES method (Generalized Minimal Residual Method).

Such methods were implemented in own codes created by the authors of this study using Octave® and with the support of free of charge available packages.

As the Equation 4 is a function of two variables defined inside the minimums and maximums ISE and OEI values that the companies operated, the function domain is the type $[x_i,x_f]X[y_i,y_f]\rightarrow R$. It is known that every continuous function reaches minimums and maximums within closed intervals (Stewart, 2013).

Thus, the minimums and maximums values of the Cobb-Douglas type functions and their optimal values of *OEI** and *ISE**, which maximize or minimize these functions, were determined by the analysis of the critical points and functions values in the domain border. Thus, an optimal relation is obtained for each component, such as Equation 5.

$$Optimal\ Relation = \frac{OEI^*}{ISE^*}\ (5)$$

Finally, to verify if the banks of the sample are operating in an optimal way, the reference value and the results of the optimal relation were compared using Confidence Intervals, with 95% of confidence, such as Equation 6 (Morettin; Bussab, 2017).

$$Confidence\ Interval = \overline{x} \pm 2.179 \cdot \frac{s}{\sqrt{n}}, (6)$$

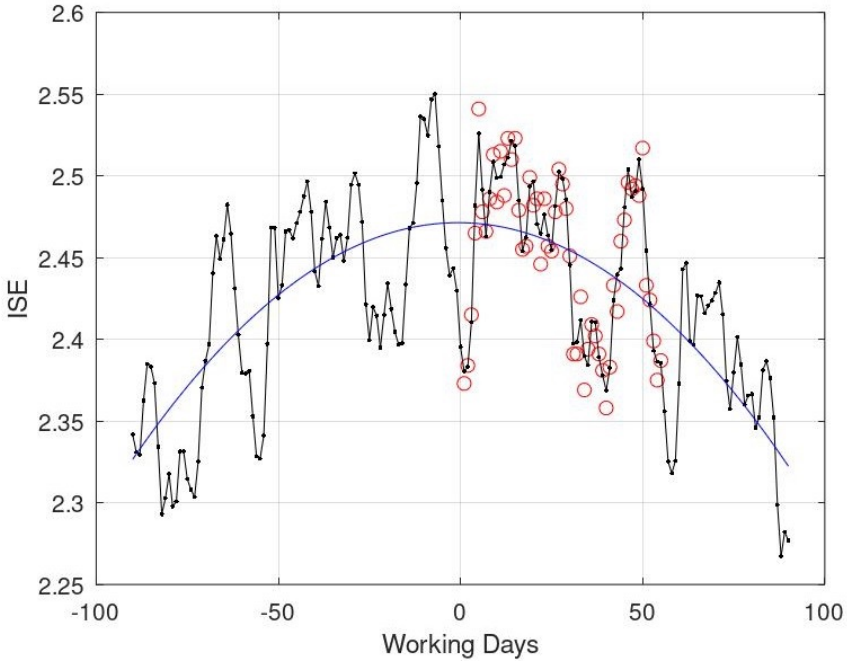
$\overline{x}$ equal to the arithmetic mean of the sample, s the standard deviation of the sample and n the size of the sample. The t-student distribution was used (adopting tc = 2.179 for 95% of confidence) due to each component having a thirteen-month data, since the period of the study is from December 2022 to December 2023.

4 DATA AND RESULTS

This research aimed to verify if the three largest banks in Brazil (Itaú, Bradesco and Santander) operated in an optimal way for the four components of the Operational Efficiency Index (OEI), which are: Personnel Expenses (Personnel_Exp), Administrative Expenses (Adm_Exp), Financial Intermediation Result (FinInter_R) and Services Revenues (Serv_R). It should be noted that the percentage of participation in the Corporate Sustainability Index (ISE) portfolio of each bank will also be considered for the Cobb-Douglas function.

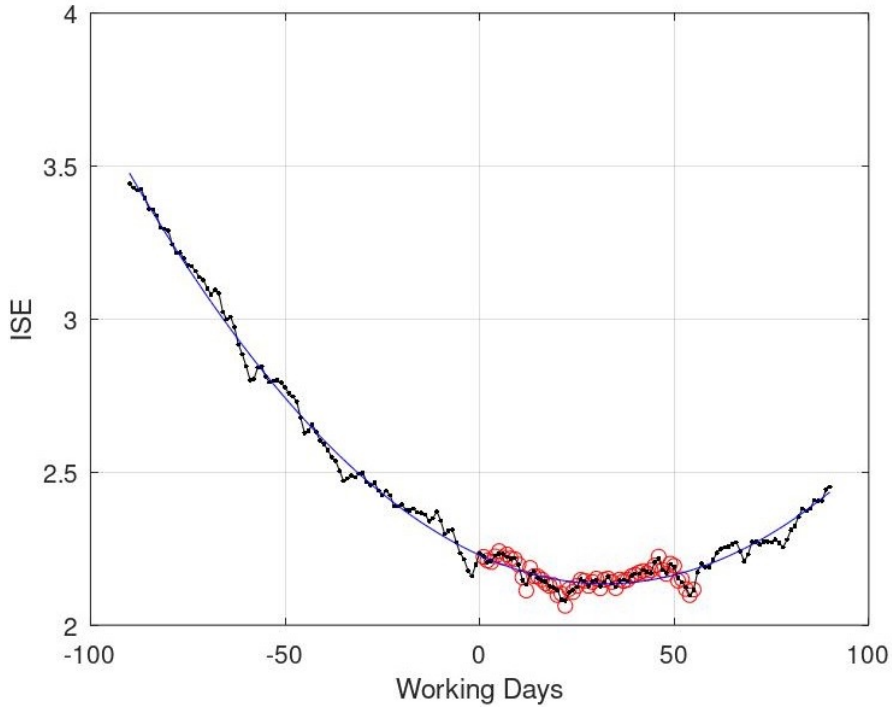
Figures 1 to 3 demonstrate the daily forecasts of the percentage of participation in the ISE portfolio. The results of the linear system which meet the parable (quadratic curve adjustments) are showed in blue, of GMRES method in black, and the data collected daily from B3 in red. Figure 1 to 3 refer to Bradesco, Itaú and Santander ISE participation, respectively.

Figure 1 – Projections of Bradesco's Percentage of Participation in the Corporate Sustainability Index Portfolio



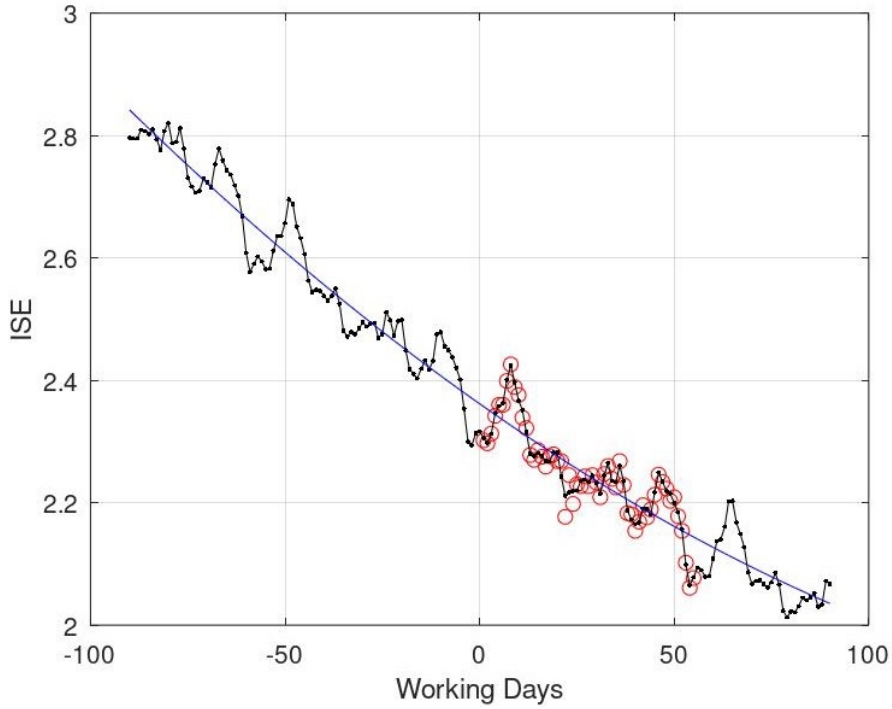
Source: Made by the Authors (2023).

Figure 2 – Projections of Itaú's Percentage of Participation in the Corporate Sustainability Index Portfolio



Source: Made by the Authors (2023).

Figure 3 – Projections of Santander's Percentage of Participation in the Corporate Sustainability Index Portfolio



Source: Made by the Authors (2023).

Figures 1 to 3 of the banks of the sample demonstrate different behaviour and oscillation between them in ISE participation portfolio. Bradesco's forecast of participation in the Corporate Sustainability Index varies considerably during the period, while Itaú's participation tends to fall and then rise after 90 days (working day number zero in Figure 2). Interestingly, Santander's forecasted participation is estimated to fall during the period analysed. Considering that the participation in the ISE depends on firms voluntarily completing questionnaires, these patterns may reflect market expectations regarding the bank's willingness to engage in this process, which can be costly, as well as perceptions about the firm's sustainability performance, despite the importance of sustainability practices for investors, as mentioned above. It is worth mentioning that Figures 1 to 3 show projections of 180 days of the Index, being 90 days back and 90 days forward.

Table 1 presents Itaú monthly data (same scale) for the Cobb-Douglas function, considering historical and future monthly data from December 2022 to December 2023 of the operational efficiency components and the two indexes adopted in the study. The forecasts correspond to the period between July 2023 and December 2023.

Table 1 – Itaú Monthly Data

Month	Personnel_Exp	Adm_Exp	FinInter_R	Serv_R	OEI	ISE
Dec/22	(7,435)	(6,369)	13,408	11,689	41.05%	3.40%
Jan/23	(7,373)	(6,266)	13,087	11,720	40.74%	3.14%
Feb/23	(7,233)	(6,200)	13,311	11,732	40.44%	2.77%
Mar/23	(7,067)	(6,197)	14,186	11,698	40.17%	2.49%
Apr/23	(6,928)	(6,244)	15,487	11,625	39.95%	2.31%
May/23	(6,858)	(6,296)	16,684	11,555	39.77%	2.19%
Jun/23	(6,872)	(6,301)	17,105	11,557	39.62%	2.13%
Jul/23	(6,958)	(6,226)	16,187	11,693	39.47%	2.16%
Aug/23	(7,087)	(6,080)	13,722	11,986	39.29%	2.18%
Sep/23	(7,219)	(5,914)	9,986	12,402	39.02%	2.13%
Oct/23	(7,323)	(5,801)	5,701	12,845	38.63%	2.18%
Nov/23	(7,380)	(5,808)	1,822	13,191	38.10%	2.27%
Dec/23	(7,386)	(5,968)	(7,751)	13,324	37.49%	2.40%
Mean	(7,163)	(6,129)	10,995	12,078	39.52%	2.44%
Standard Deviation	212	194	7,157	641	1.02%	0.41%

Source: Made by the Authors (2023).

The monthly data of Itaú operational efficiency components presented in Table 1 show a similar trend to the quarter data obtained from Itaú Investors Relations website and financial statements. Table 2 presents the six variables (monthly scale) also used for Bradesco.

Table 2 – Bradesco Monthly Data

Month	Personnel_Exp	Adm_Exp	FinInter_R	Serv_R	OEI	ISE
Dec/22	(5,635)	(5,766)	17,608	5,263	48.19%	2.36%
Jan/23	(5,579)	(5,640)	18,530	5,255	48.02%	2.37%
Feb/23	(5,546)	(5,492)	19,403	5,226	47.36%	2.42%
Mar/23	(5,542)	(5,359)	19,989	5,175	46.46%	2.45%
Apr/23	(5,566)	(5,274)	20,134	5,117	45.70%	2.47%
May/23	(5,614)	(5,257)	19,756	5,075	45.41%	2.47%
Jun/23	(5,681)	(5,310)	18,821	5,077	45.77%	2.46%
Jul/23	(5,766)	(5,426)	17,314	5,138	46.77%	2.43%
Aug/23	(5,871)	(5,582)	15,255	5,259	48.20%	2.48%
Sep/23	(5,994)	(5,751)	12,732	5,417	49.72%	2.43%
Oct/23	(6,128)	(5,905)	9,937	5,571	50.94%	2.42%
Nov/23	(6,256)	(6,021)	7,181	5,679	51.59%	2.40%
Dec/23	(6,357)	(6,085)	4,857	5,706	51.58%	2.33%
Mean	(5,810)	(5,605)	15,501	5,304	48.13%	2.42%
Standard Deviation	286	284	5,197	220	2.21%	0.05%

Source: Made by the Authors (2023).

The monthly data of the four operational efficiency components of Bradesco (Table 2) demonstrate a similar trend of Bradesco quarter data, as well as Itaú data presented on Table 1. This can also be observed on Santander monthly data, as shown in Table 3, on the following page, which may be an indication that the forecasts calculated on this study are reasonable for the three largest banks in Brazil. Therefore, it demonstrates the reliability of the adopted method in this study, which can be used by investors, analysts and managers decision-making and forecasting.

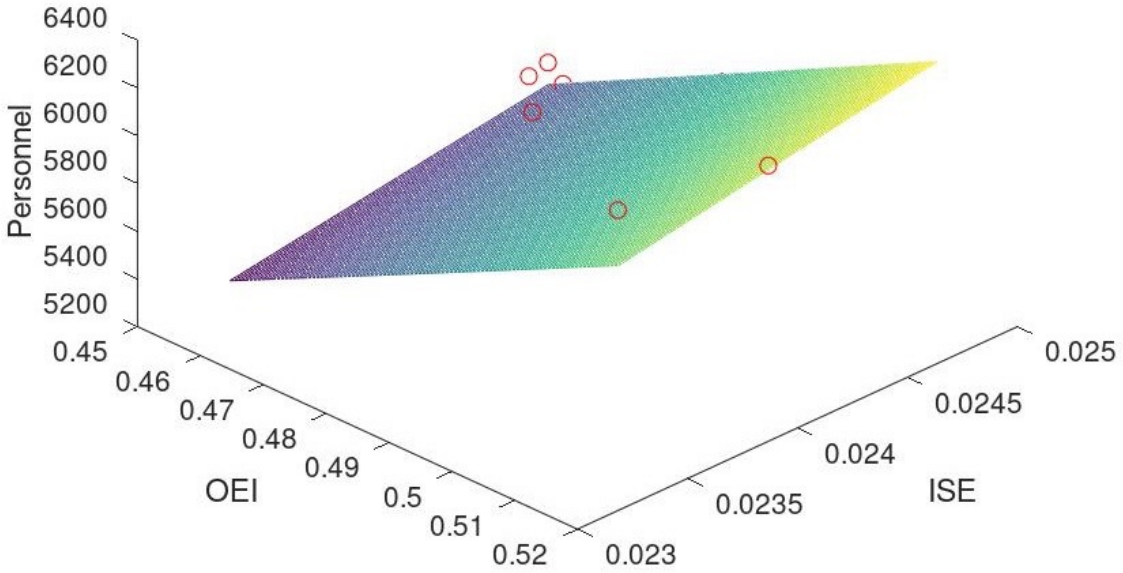
Table 3 – Santander Monthly Data

Month	Personnel_Exp	Adm_Exp	FinInter_R	Serv_R	OEI	ISE
Dec/22	(2,074)	(3,384)	3,926	3,577	40.27%	2.80%
Jan/23	(2,127)	(3,323)	3,163	3,544	40.74%	2.75%
Feb/23	(2,169)	(3,275)	2,887	3,493	40.93%	2.62%
Mar/23	(2,202)	(3,260)	3,331	3,436	41.00%	2.50%
Apr/23	(2,230)	(3,279)	4,507	3,389	41.16%	2.41%
May/23	(2,260)	(3,311)	6,141	3,366	41.56%	2.33%
Jun/23	(2,299)	(3,330)	7,713	3,376	42.31%	2.24%
Jul/23	(2,349)	(3,315)	8,600	3,420	43.39%	2.18%
Aug/23	(2,407)	(3,259)	8,274	3,485	44.67%	2.32%
Sep/23	(2,468)	(3,173)	6,484	3,553	45.95%	2.23%
Oct/23	(2,525)	(3,085)	3,366	3,596	47.00%	2.15%
Nov/23	(2,573)	(3,020)	(5,782)	3,592	47.66%	2.09%
Dec/23	(2,609)	(2,994)	(4,622)	3,527	47.87%	2.05%
Mean	(2,330)	(3,231)	3,691	3,489	43.42%	2.36%
Standard Deviation	174	125	4,433	84	2.85%	0.24%

Source: Made by the Authors (2023).

Starting from the monthly database, three-dimensional (3D) graphics were created containing the OEI, each OEI component, and ISE data for each bank in the sample. One example is provided in Figure 4, on the following page.

Figure 4 – Cobb-Douglas Function of Personnel Expenses, Operational Efficiency Index and Corporate Sustainability Index of Bradesco



Source: Made by the Authors (2023).

The multivariate adjustment presented in Figure 4 shows a correlation between Personal and OEI data of 0.89 and a coefficient of determination of 0.79. The correlation between Personal and ISE data was 0.80 and the coefficient of determination was 0.64.

Subsequently, minimum e maximum values and optimal values and relations were calculated for each operational efficiency component, OEI and ISE of Itaú, Bradesco and Santander. The Cobb-Douglas function was minimized for Personnel and Administrative Expenses and maximized for Financial Intermediation Result and Services Income, as it can be a way for a company to reduce costs, increase revenues, and, consequently, increase its earnings. It should be noted that there are other ways to a firm increase earnings. However, the study focuses specifically on cost reduction and increase of revenues for this analysis. Table 4 shows the minimums and maximums of the Operational Efficiency Index and Corporate Sustainability Index.

Table 4 – Minimums and Maximums of the Operational Efficiency Index and Corporate Sustainability Index

Bank	**Itaú**		**Bradesco**		**Santander**	
Index	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
OEI	37.49%	41.05%	45.41%	51.59%	40.27%	47.87%
ISE	2.12%	3.40%	2.33%	2.48%	2.05%	2.80%

Source: Made by the Authors (2023).

Table 4 shows a minor variation on Bradesco ISE participation and a higher variation of OEI, corroborating with the results observed in Figure 1. This may also indicate a higher performance on Bradesco sustainable practices. Additionally, Santander presents a higher variation in the Operational Efficiency Index, which suggests a lower operational efficiency during the period and sample of this research, while Itaú shows the lowest variation for this index. Therefore, greater variation in the Corporate Sustainability Index and the Operational Efficiency Index may influence investors' decision-making and support managers to better focus their efforts and strategies, given the importance of these indexes for the banking industry and the capital markets. Table 5 shows the optimal values and relations for each bank of the sample.

Table 5 – Optimal Values and Relations

Bank	**Itaú**		**Bradesco**		**Santander**	
Operational Effiency Component	**Optimal Value**	**Optimal Relation**	**Optimal Value**	**Optimal Relation**	**Optimal Value**	**Optimal Relation**
Personnel_Exp	(6,699)	19.3	(5,313)	19.5	(2,097)	14.4
Adm_Exp	(5,751)	19.3	(5,243)	18.3	(2,998)	14.4
FinInter_R	29,021	19.3	23,884	18.3	11,998	19.7
Serv_R	14,479	11.0	5,645	20.8	3,996	17.1

Source: Made by the Authors (2023).

For Itaú, the lowest possible Personnel and Administrative Expenses and the highest possible Financial Intermediation Results correspond to an Operational Efficiency Index that is 19.3 times higher than the Corporate Sustainability Index, and the highest possible Services Income, 11 times. The division between the OEI and ISE mean monthly data of Itaú generated a result of 11.011. It also was obtained a confidence interval between 15.205 and 17.804, considering 95% of confidence. Thus, it indicates that Itaú does not operate near the optimal relation between these indexes for the operational efficiency components.

For Bradesco, the lowest possible Personnel Expenses correspond to an OEI level 19.5 times higher than the ISE, the lowest Administrative, 18.3 times, the highest possible Financial Intermediation Result, 18.3 times, and the highest possible Services Income correspond to a level of 20.8 times. The division between the OEI and ISE mean monthly data of Bradesco generated a result of 19.889. The confidence interval remained around 19.165 and 20.613, with 95% confidence, showing that Bradesco operated close to the optimal relation amongst both indexes only for Personnel Expenses, considering the sample and period of the study. The Services Revenue was close to the confidence interval, but outside of it.

For Santander, the lowest possible Personnel and Administrative Expenses correspond to an OEI 14.4 times high than ISE, 19.7 times for the highest possible Financial Intermediation Result and 17.1 times for the highest possible Services Income. The division between the OEI and ISE mean monthly data of Santander generates a result of 18.666. The confidence interval remained around 16.870 and 20.461 for 95% confidence. Thus, Santander operates near the optimal relation for the Financial Intermediation Result and Services Income, being the bank that operated close

to this relation for more operational efficiency components.

5 DISCUSSIONS

The comparison between the optimal results of the three banks that composes the sample show that only Itaú did not have optimal relations on any of the four operational efficiency components. For Bradesco, it was verified an optimal relation only on Personnel Expenses, while for Santander it was observed on Financial Intermediation Result and Services Income, which was the bank that mostly showed optimal relations for the components and period analysed.

A possible reason for Bradesco and Itaú Financial Intermediation Result, as well as for Itaú Services Income not showing optimal results is the scenario of the increase in default in Brazil, because it increases the Expected Credit Losses (ECL), which composes the Financial Intermediation Results and influences the financial institutions income. Thus, the adoption of strategies by these organizations is essential for the improvement of the scenario and the credit portfolio control and monitoring.

The adoption of such strategies is also associated with the importance of the corporate governance to the organizations, economy and society, given that a good governance structure is necessary to mitigate conflicts of interest amongst managers and stakeholders on redefining strategies for short, medium and long-term. Furthermore, companies must disclose their actual actions and future perspectives, such as the adoption of sustainable practices in an efficient matter, without leaving behind their competitive advantage.

Therefore, the adoption of sustainable practices is more costly in the short-term but tend to generate better results in the future and optimize the operational performance (Silva; Santos; Alcoforado, 2021; Nicoletti Junior et al., 2022), justifying the analysis of both indexes for the largest banks in the Brazilian context, which is an emerging market, and contributing to investors' decision-making, managers' strategic choices, and analysts' forecasts.

Additionally, none of the three banks of the sample disclosed to the market if their administrative expenses contain expenses related to sustainability for the period analysed. Thus, they can report sustainable practices and values to investors, as it provides a higher long-term value generation, despite being more expensive on short-term.

The results extend the findings of Belasri; Gomes; Pijourlet (2020) study, which observed that corporate social responsibility has a positive impact on the efficiency of 184 banks, located in 41 countries, considering the period from 2009 to 2015. Thus, sustainability can increase bank efficiency, generating benefits, such as a better use of resources and the development of the business model.

It should be noted that companies must evaluate if the optimal value is possible to maintain and develop the operations, because reducing expenses or increasing revenues can impact the business model and organizational strategies. Therefore, income and expenses efficiency must be evaluated as a whole, aiming business continuity in a sustainable manner.

6 CONCLUSIONS

The objective of this research was to obtain the optimal value between efficiency and sustainability for the four operational efficiency components (Personnel Expenses, Administrative Expenses, Financial Intermediation Result and Services Income), according to the literature, for the three largest banks in Brazil (Itaú Unibanco, Bradesco and Santander). It was considered a period between the fourth quarter of 2022 and the second quarter of 2023. It is worth pointing out that Personnel Expenses, Administrative Expenses, Financial Intermediation Result and Services Income are essential for the operations continuity of banking institutions.

The adoption of the Operational Efficiency Index on this study enables to analyse the influence of efficiency on banks evaluation, by creating a relation between the OEI and the Corporate Sustainability Index. Additionally,

the participation in the ISE depends on firms voluntarily completing questionnaires, the forecasts made for the banks participation on the portfolio may reflect market expectations regarding the bank's willingness to engage in this process, which is more costly in the short-term, but generates better results in the future (Silva; Santos; Alcoforado, 2021; Nicoletti Junior et al., 2022), justifying the analysis of both indexes for the largest banks in an emerging market.

Therefore, this association allows the interested parties to verify the importance of relating efficiency and sustainability, to support investments evaluation and decision-making, and to monitor the establishment of an efficient and sustainable business model by disclosure, which improves the operational structures of banking institutions, generating value to them.

For this purpose, data referring to ISE, OEI as well as the four components for the three banks of the sample was collected. The data was adjusted for the same time basis (monthly) by means and curve adjustments.

Furthermore, the oscillation curve adjustments were constructed and the optimal values and relations of the Operational Efficiency Index components and the Corporate Sustainability Index portfolio by applying the Cobb-Douglas function and elaborating the confidence intervals for the three banks of the sample. Therefore, it was possible to analyse, in general, if these organizations operated in an optimal way.

Santander operated close to the optimal relation on more operational efficiency components (Financial Intermediation Result and Services Incomes), Bradesco operated close to this relation on one of the components (Personnel Expenses), and Itaú did not operate close to this relation on any of the four operational efficiency components, considering the study period.

The results can be seen as a reflex of the increase on default of these banks, affecting the Brazilian economy and the reported results, characterizing as a reason for strategies and business model revisions.

Therefore, it is important to analyse the Operational Efficiency Index components, considering the perspectives of efficiency and sustainability, which was used as a proxy of corporate governance. Such relevance is also seen in forecasts trends, as well by adopting optimal values and relations. Thus, this study contributes to investors' decision-making, managers' strategic choices, and analysts' forecasts. In addition, this study contributes by presenting the construction of a market forecast model, aiming to support stakeholders' investments evaluation and decision-making, based on the Cobb-Douglas function, establishing the optimal value between efficiency and sustainability for each OEI. It also contributes with the literature by using mathematical models (polynomial curve adjustments, trigonometric adjustments for data oscillations and Cobb-Douglas function), which is not much used in Applied Social Sciences. It should be noted that, to the best of the authors' knowledge, this is the first study to compare the Operational Efficiency Index and the Corporate Sustainability Index for the three largest banks in Brazil, which is an emerging market, while also adopting this methodology.

However, this study has limitations, which are: (i) it relies on daily ISE portfolio participation that were manually collected; (ii) the analysed period (one year) and sample (three banks) are relatively short, which affects the generalization of the results; and (iii) it combines reported accounting information with the corresponding forecasted data and does the same for the ISE data, which could introduce bias into the study. In addition, other factors may affects the ISE participation and operational performance, such as macroeconomic scenarios and firm-specific events. For future research, it is suggested to increase the period of the study for the Brazilian context, in order to evaluate whether and how it changes over time, to replicate the method adopted in foreign banks, comparing with the results of this study. It is also suggested to obtain a general optimal value, aiming to optimize simultaneously all the Operational Efficiency Index components.

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