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INCOME DIVERSIFICATION AND ITS EFFECTS ON PROFITABILITY AND RISK: A STUDY OF BRAZILIAN BANKS

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Abstract

Banks generally have two main types of income: interest-related income, or simply interest income, and non-interest-related income, or non-interest income. This study presents an analysis of the impact that income diversification has on profitability (measured by ROE and ROA), insolvency risk (measured by ZScore), and risk-adjusted return (measured by the ratio of ROE and ROA to their respective standard deviations) of banks. The analysis considers diversification between income groups (interest and non-interest) and diversification within each group, where different types of interest and non-interest income were considered. The sample used consists of data from 16 representative Brazilian banks of the National Financial System (SFN) for the period from 2012 to 2021, with eight state-owned banks and eight private banks; almost entirely data were collected from the IF.data system of the Central Bank of Brazil (Bacen). We adopted a multiple linear regression model with balanced panel data, employing the Ordinary Least Squares (OLS) method with fixed effects, considering both the fixed effect of entities and the fixed effect of time, and using, in addition to income diversification ratios, other control variables commonly used in literature. Although the literature suggests that income diversification contributes to risk reduction, increased profitability, and improved risk-adjusted returns, our statistical analysis does not provide significant evidence to support these associations. Sample limitations may explain this outcome, highlighting the need for further research to assess this relationship.

Keywords: Banks; Diversification; Insolvency Risk; Profitability.

Resumo

Os bancos, de maneira geral, possuem dois grandes tipos de receitas: as relacionadas a juros, normalmente chamadas na literatura de receitas interest, e as receitas não relacionadas a juros, comumente chamadas de receitas noninterest. Este estudo apresenta uma análise do impacto que a diversificação das receitas tem sobre a rentabilidade (medida pelo ROE e pelo ROA), o risco de insolvência (medido pelo ZScore) e o retorno ajustado ao risco (medido pela razão do ROE e do ROA pelos seus respectivos desvios-padrão) dos bancos, de modo que é analisada tanto a diversificação entre os grupos de receitas (interest e noninterest) quanto a diversificação dentro de cada um desses grupos, casos em que foram considerados os diferentes tipos de receitas interest e noninterest. A amostra utilizada é composta de dados de 16 bancos brasileiros representativos do Sistema Financeiro Nacional (SFN) para o período de 2012 a 2021, sendo oito bancos públicos e oito bancos privados; os dados foram coletados, quase em sua totalidade, do sistema IF.data do Banco Central do Brasil (Bacen). Foi adotado um modelo de regressão linear múltipla com dados em painel balanceado, empregando o método dos Mínimos Quadrados Ordinários (MQO) com efeitos fixos, sendo considerado tanto o efeito fixo das entidades quanto o efeito fixo do tempo e utilizando, além dos índices de diversificação de receitas, outras variáveis de controle comumente utilizadas na literatura. Não foram encontradas evidências robustas de contribuição da diversificação das receitas bancárias sobre a rentabilidade, o risco de insolvência e o retorno ajustado ao risco para os dados da amostra, não sendo possível concluir que a diversificação de receitas tem, por si só, um impacto positivo nos bancos.

Palavras-chave: Bancos; Diversificação; Rentabilidade; Risco de Insolvência.

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INTRODUCTION

Over time, banks have expanded their sources of income by incorporating activities beyond traditional financial intermediation. In Brazil, Resolution 1,524 of the National Monetary Council (CMN), enacted in 1988, allows the organization of commercial banking, investment banking, development banking, and credit society activities under a single legal entity, the so-called “Multiple Bank”.

Nowadays, banks generate revenue from two primary sources: interest-related income (or simply interest income), derived from traditional financial intermediation activities, and non-interest-related income (or merely non-interest income), which includes fees from several services such as insurance, brokerage, and securitization.

The pursuit of income diversification is aligned with financial theories on risk reduction, notably the modern portfolio theory, suggesting that uncorrelated income streams could lower risk while enhancing profitability. As a result, it has become an important research topic, given its potential impact on managerial decisions, regulatory policies, and even consumer interests, as it influences the financial stability of the banking sector.

This work aims to contribute to the literature on the impact of bank income diversification on their earnings and risks through an empirical analysis conducted on data from Brazilian banks from 2012 to 2021 in a balanced panel. The diversification impact, both between interest and non-interest income and within each of these types, on profitability – measured by return on assets (ROA) and return on Equity (ROE) – on risk-adjusted profitability – measured by the ratio of ROA and ROE to their respective standard deviations over the period covered by the sample – and on the insolvency risk of institutions – measured by ZScore – is tested.

A multiple linear regression model with balanced panel data was adopted, adding control variables commonly employed in the literature. We collect most of the data from the IF.data system of the Central Bank of Brazil (Bacen), which aggregates data from the Financial Institutions Chart of Accounts (Cosif).

We structure the paper into five sections, with this introduction being the first, which outlines the topic and defines the paper's objectives and structure.

Section 2 provides a literature review on the deregulation of the banking system, the diversification of bank income, and the impact of bank income diversification on financial institutions, aiming to contextualize the topic and highlight its importance in the literature. Next, section 3 details the methodology employed in the study, showing the sample selection process, defining the variables adopted, explaining the data gathering, and describing the model used.

Section 4 presents the results, analysis of the findings, and discussion, while section 5 provides the final considerations.

LITERATURE REVIEW

This section provides a literature review regarding the deregulation of the banking system, the diversification of bank income, and the impact that diversification has on banking institutions.

Deregulation of the banking system

The consolidation of the Brazilian financial system occurred due to various factors, including the deregulation of banking services (METZNER; MATIAS, 2015). According to Fortuna (2015), the banking model imported by the Brazilian Empire was European, so commercial banks in Brazil operated mainly with deposit and loan operations, which lasted until the mid-20th century. Since the 1950s, the author continues to say that banks have spread across the country, and the National Financial System (SFN) has begun to solidify.

In 1965, the Capital Market Law was published, inspired by the idea of segmentation and specialization, typical of the American model of that period, in an attempt to reduce risks, decrease conflicts of interest (providing greater segmentation among financial intermediaries), and increase efficiency (METZNER; MATIAS, 2015; FORTUNA, 2015). However, the specialization model did not meet market needs, and seeking economies of scale and better system rationalization, banks began to act as leaders of large conglomerates, so that these institutions carried out many distinct activities and were controlled by a single holding company (METZNER; MATIAS, 2015; FORTUNA, 2015).

Assaf Neto (2021) highlights that the movement towards forming financial conglomerates is a consequence of the institutions' interest in promoting synergy in their operations, so acting simultaneously in financial intermediation and other operations was strategic for the banks' growth. Thus, the author continues, the so-called "multiple banks" naturally emerged in the Brazilian market, bringing together all these activities under a single decision-making unit.

It was only at the end of the 1980s, however, that the monetary authorities began to recognize the structure of the "Multiple Bank" through the publication of Resolution 1,524 of 09/22/1988 by the CMN, which allowed financial institutions to organize commercial banking investment banking, development banking, and credit society activities under a single legal entity (FORTUNA, 2015; ASSAF NETO, 2021).

Baele, Jonghe, and Vander Vennet (2007) describe similar deregulation in the European and North American banking systems. The authors mention that the Glass-Steagall Act prohibited American banks from engaging in non-banking activities. Only in 1999 did the Gramm-Leach-Bliley Act come into effect, allowing banks to seek greater diversification as Financial Holding Companies. The authors also comment that in Europe, this deregulation occurred earlier and more comprehensively, in 1989, through the Second Banking Coordination Directive, which laid the foundations for the diversification of European banks' activities, allowing Europeans to engage in a broader range of activities than Americans and to operate in these markets for a longer time.

Ferreira, Zanini, and Alves (2019) conclude that the deregulation enabled the diversification of financial institutions' activities and allowed for a movement of banking consolidation in Brazil. Meslier, Tacneng, and Tarazi (2014) add that the deregulation and the expansion of banking activities resulted in a change in banks' income profiles in general, increasing non-traditional sources of income.

Providing an example of this shift in profile, Stiroh (2004a) reports that non-interest income increased from 25% in 1984 to 43% in 2001 of the total operating income of American banks, while Elsas, Hackethal, and Holzhäuser (2010) list that the average levels of diversification of the world's largest banks were almost one-third higher in 2003 than in 1996.

Bank income diversification

Markowitz (1952) when initiating the study that originates his Portfolio Theory, considers the rule that investors consider, or should consider, expected return as something desirable and the variance of these returns as something undesirable. In his work, the author concludes that considering a specific range of assets, there are diversified portfolios that produce efficient combinations of expected return and variance so that diversification would maximize the expected return for each associated risk level. Thus, an investor informed of the achievable combinations of expected return and variance could choose the portfolio that best meets their risk appetite, considering that the portfolio with the maximum expected return is not necessarily the one with the minimum variance.

Assaf Neto (2021) also mentions that the diversification proposed by Markowitz (1952) allows for reducing or even eliminating a portfolio's diversifiable or non-systematic risk. However, it does not eliminate the systematic or non-diversifiable risk of the portfolio. Furthermore, Markowitz (1952) emphasizes that diversification, to reduce risk, must be done with low-correlated assets.

Ferreira, Zanini, and Alves (2019) infer that, based on Markowitz (1952), we expect that the diversification of bank income would reduce a bank's risk, as non-interest income would not be subject

to the same risk factors as traditional interest income. Chiorazzo, Milani, and Salvini (2008) corroborate this argument by stating that when researchers consider risk, we believe that the diversification of income sources should reduce a bank's total risk, as the activities generating non-interest income would be uncorrelated or, at least, low-correlated with those producing interest income.

Busch and Kick (2009) comment that the income diversification strategy can help banks reduce risks and stabilize their profits, provided these income sources are imperfectly correlated, also in line with what Markowitz (1952) says. However, the authors caution that some activities generating non-interest income have a much higher associated risk than other forms of income and, therefore, could contribute to destabilizing banks individually and the banking system as a whole. The authors cite, for example, that the importance of activities such as loan securitization and credit derivatives has increased significantly in recent years, which, on the one hand, helped diversify bank income but, on the other hand, came with greater risk-taking, mainly due to the complexity of these instruments.

Similarly, DeYoung and Roland (2001) state that the common sense among bankers, analysts, and regulators would be that non-interest income is more stable than interest income because they are, in theory, less sensitive to interest rate variations and financial crises, so the combination of the two types of income would help reduce the risk of commercial banks. However, the authors counter this idea by explaining that loan relationships may be more stable than relationships with customers of other activities, and that could increase credit supply; there is an increase in variable interest expenses, while to increase the supply of different activities, fixed personnel costs incurred, which would increase the institution's operational leverage.

Baele, Jonghe, and Vander Vennet (2007) analyze, citing Saunders (1994), the potential advantages that diversified banks would have over specialized banks, stating that, in terms of profitability, it would be a matter of the benefits of conglomeration exceeding its costs. The authors argue that forming financial conglomerates would be beneficial if the combination of various activities increased the institutions' income-generating capacity and/or if the integration of activities led to greater operational synergy, generating economies of scope. Additionally, they mention that the information banks capture in loan relationships could facilitate the efficient provision of other services. Conversely, the information captured in other services could improve the entity's credit risk management.

Following this reasoning, Baele, Jonghe, and Vander Vennet (2007) comment that, theoretically, just to clarify whether the potential benefits of diversifying banking activities outweigh the associated costs. Empirically, due to data limitations and econometric difficulties, the authors continue by saying that the literature has difficulty assessing the real impact of economies of scope or agency costs in the banking sector, which we will explore in the following subsection.

Stiroh (2004a) emphasizes that the ability to reduce risk is a topic of great importance for the banking sector, including its regulators. The author argues that if income diversification can reduce banks' risk, it may be reasonable to reduce capital requirements for institutions with diversified income and for the managers of these banks to reallocate their resources. DeYoung and Roland (2001) also highlight the importance of this issue for regulators, who are responsible for preserving the safety and soundness of commercial banks; for managers, who have financial and professional interests in the banks; and for consumers, who have relationships with banks harmed by increased volatility in these institutions' earnings.

Literature on the impact of income diversification on banks

International literature presents divergent results regarding the impact of income diversification on the profitability and risk of banking institutions. Generally, studies focusing on the American banking system are still looking for a clear benefit for entities with increased income diversification. In contrast, we typically associate diversification with gains in the risk-return relationship in European banks.

In the scope of American banks, DeYoung and Roland (2001) found, for a sample of 472 banks and data from 1988 and 1995, that an increase in non-interest income was associated with increased volatility but also increased return. Stiroh (2004a) analyzed bank data between 1970 and 2001 and concluded that the results show a worsening risk-return relationship with increased non-interest income. Stiroh (2004b) reached a similar conclusion by analyzing community banks between 1984 and 2000. Stiroh and Rumble (2006) found, using data from over 1,800 financial conglomerates between 1997 and 2002, that income diversification is associated with increased risk-adjusted results. However, they caution that the costs of greater exposure to non-interest activities counterbalance these gains. Finally, DeYoung and Rice (2004) analyzed data from American commercial banks between 1989 and 2001. They found that increases in non-interest income tend to be associated with increases in profitability, increases in result variation, and a worsening of the risk-return relationship for the sample. Schreiber (2024) analyzed the impact of income diversification in US banks by size and found a 'smile' pattern in which profitability, equity capital, and credit risk in medium-sized banks reflect insensitivity to income diversification compared to large and small-size groups, which might indicate some relative advantage of medium banks regarding income diversification benefits.

In the European scenario, Baele, Jonghe, and Vander Vennet (2007) analyzed banks from 17 European countries between 1989 and 2004, finding a strong positive relationship between company value and its degree of diversification. Busch and Kick (2009) found, for German banks, a better risk-

return relationship in banks more exposed to non-interest income, cautioning that there is also greater volatility. Köhler (2014) separated German banks into retail-oriented and investment-oriented and concluded that increasing the share of non-interest income reduces the risk of retail-oriented banks and significantly increases the risk of investment-oriented banks, with risk measured by ZScore. In turn, Chiorazzo, Milani, and Salvini (2008) analyzed Italian banks and found a positive relationship between income diversification and risk-adjusted returns.

DeYoung and Rice (2004) comment that some regulatory and structural differences could explain the difference between the findings for European and American banks. The authors point out that many American banks had only recently engaged in fee-based services, and thousands of smaller community banks needed the size and expertise to operate in these markets. On the other hand, in Europe, financial institutions were already familiar with this type of service, and community banks needed to be more relevant, which aligns with what Baele, Jonghe, and Vander Vennet (2007) describe the deregulation process of these banking systems.

In the Asian context, we obtain conclusions similar to those of the latter in some studies. Lee, Hsieh, and Yang (2014) researched data from 2,372 banks in 29 Asia-Pacific countries, separating the sample into banks inserted in financial systems with different characteristics, indicating that other types of non-interest income have different impacts depending on the structure in which the entity is inserted Moudud-Ul-Huq *et al*. (2018) analyzed banks from five countries between 2011 and 2015, indicating that income diversification had a robust positive impact on performance and risk reduction, while credit portfolio diversification varied from country to country. Wang and Lin (2021), when examining data from 14 Asia-Pacific countries between 2011 and 2016, noted that increased diversification reduced risk in emerging countries, while there was no significant impact in developed countries. Li and Zhang (2013), evaluating the Chinese context from 1986 to 2008, suggest that increasing non-interest income could worsen the risk-return relationship. Meslier, Tacneng, and Tarazi (2014) found a positive impact on profitability and risk-adjusted profitability with increased diversification for Filipino banks, noting that this impact is more significant in foreign than domestic banks. Ngoc Nguyen (2019) found that diversification worsened performance and risk in Vietnamese banks but also mentioned that diversification reduced risk for listed banks. Mehmood and De Luca (2023) collected data from 372 banks from 14 Asian emerging markets, and their results indicate a positive relation between non-interest income and bank credit risk, pointing out that the impact was higher before the Covid-19 pandemic and significantly reduced during the pandemic period.

Other studies in the area include Sissy, Amidu, and Abor (2017), who found a positive relationship between diversification and risk-adjusted return in banks from 29 African countries,

Williams (2016), who studied Australian banks and concluded that non-interest income does not generate the expected benefits of diversification, Sanya and Wolfe (2011), who studied 11 emerging countries and whose results indicate that diversification both between interest and non-interest income and within these groups improves profitability and reduces insolvency risk, Nguyen (2012), who studied banks from 28 countries between 1997 and 2004 and that risk-adjusted return increased with the increase in non-interest income in subsequent years; Elsas, Hackethal, and Holzhäuser (2010), who analyzed large banks from 9 developed countries, found a positive relationship between diversification and profitability, and Saklain and Williams (2024), who studied commercial banks from 126 countries and concluded that non-interest income was not only positively associated with bank profitability but also found some evidence suggesting it was risk-decreasing.

Finally, in the Brazilian scenario, Ferreira, Zanini, and Alves (2019) analyzed a sample of Brazilian banks between 2003 and 2014 and found that return, risk, and risk-adjusted return increased with the increase in non-interest income. However, the relationship with risk was statistically insignificant. The authors also found that the share of credit operation income was related to higher returns, while the share of securities income was associated with poorer profitability and higher risk. Vieira and Girão (2016) analyzed 88 institutions between 1997 and 2015 and did not find, for the sample, an influence of income diversification on banks' insolvency risk; however, the authors found evidence that listed banks managed to reduce insolvency risk with diversification, which would not occur with closed-capital banks.

METHODOLOGY

Data from 16 Brazilian financial institutions were collected from 2012 to 2021 to test, through a multiple linear regression with balanced panel data, whether income diversification impacts the profitability, insolvency risk, and risk-adjusted return of Brazilian banks.

Sample Selection

The sample of institutions analyzed is the same adopted by Nazaré (2020), who selected the eight most prominent private banks (Itaú, Bradesco, Santander, Safra, BTG Pactual, Votorantim, Citibank, and Banco Sicoob). The eight largest state-owned banks (Banco do Brasil, Caixa Econômica Federal, Banrisul, Banco do Nordeste, Banco da Amazônia, BRB, Banestes, and Banpará) in Brazil, considering their credit portfolios. The author also mentions that these sixteen banks represented, in 2018, more than

77% of the credit portfolio and more than 73% of the total assets of SFN companies, making these institutions a representative sample of the Brazilian banking system. Table 1 contains the banks used in the sample and the information cited by Nazaré (2020) regarding their representativeness, with total asset and credit operation data updated for 2021. We use account values 1.6.0.00.00-1 from Cosif of each institution for credit loans.

Table 1 - List of analyzed banks and their representativeness in the SFN

Bank	Total Assets (R$1,000)	Total Assets		Credit Loans (R$1,000)	Credit Loans	
		Percentage	Cumulative %		Percentage	Cumulative %
Itaú	1,989,883,494	16.27%	16.27%	700,065,267	15.53%	15.53%
Banco do Brasil	1,919,468,973	15.70%	31.97%	704,162,487	15.62%	31.15%
Caixa Econômica Federal	1,448,893,554	11.85%	43.81%	856,315,532	19.00%	50.15%
Bradesco	1,424,533,152	11.65%	55.46%	509,571,139	11.31%	61.46%
Santander	994,939,032	8.14%	63.60%	383,607,805	8.51%	69.97%
BTG Pactual	374,163,125	3.06%	66.66%	93,637,794	2.08%	72.04%
Safra	235,636,758	1.93%	68.58%	87,798,296	1.95%	73.99%
Citibank	133,720,263	1.09%	69.68%	12,786,411	0.28%	74.28%
Votorantim	120,228,843	0.98%	70.66%	57,159,832	1.27%	75.54%
Banrisul	104,115,621	0.85%	71.51%	37,910,306	0.84%	76.39%
Banco Sicoob	75,607,672	0.62%	72.13%	8,697,369	0.19%	76.58%
Banco do Nordeste	60,302,034	0.49%	72.62%	15,087,271	0.33%	76.91%
Banestes	33,931,307	0.28%	72.90%	5,986,076	0.13%	77,05%
BRB	30,541,161	0.25%	73.15%	20,777,288	0.46%	77.51%
Banco da Amazônia	25,952,485	0.21%	73.36%	11,224,831	0.25%	77.76%
Banpará	12,518,707	0.10%	73.47%	8,284,175	0.18%	77.94%
Sample Total	**8,984,436,181**	**73.47%**	-	**3,513,071,879**	**77.94%**	-
SFN Total	**12,229,470,097**	**100.00%**	-	**4,507,417,707**	**100.00%**	-

Source: Self elaboration. Adapted from Nazaré (2020).

It is also worth noting that Bancoob became Banco Sicoob in 2020. Thus, Bacen Reports changed its nomenclature from 2019 to 2020. The sample consists of 160 observations for these financial institutions, collected from 2012 to 2021.

Data Gathering

The accounting data of the institutions under analysis were collected from the IF.data system of the Central Bank of Brazil, accessible via the link https://www3.bcb.gov.br/ifdata/. We collect Data from the fourth quarter for the "Assets" and "Liabilities" reports and data from the second and fourth quarters for the "Income Statement" report, considering that the data from this report for these quarters are semiannual. Additionally, balance sheet data from financial institutions were collected through the link https://www.bcb.gov.br/estabilidadefinanceira/balancetesbalancospatrimoniais, considering that IF.data shows already aggregated data from Cosif accounts. As described by Bacen, the files "include information on the balances of all accounts up to level 3 of the Balance Sheets", making it impossible to reproduce some of the aggregations made in IF.data.

Dependent Variables

This work aims to measure the impact of income diversification on the profitability, risk, and risk-adjusted profitability of the institutions selected for the sample. According to Mota, Silva, and Silva (2019), among the most commonly used profitability indicators in the literature are ROE (Return on Equity) and ROA (Return on Assets), as defined below:

$$ROE_{it} = \frac{NI_{it}}{E_{Average_{it}}} \quad (1)$$

$$ROA_{it} = \frac{NI_{it}}{A_{Average_{it}}} \quad (2)$$

Where NI is the net income, $E_{Average}$ is the average equity, and $A_{Average}$ is the average total assets of each entity *i* in each period *t*, with the latter two obtained by averaging the values at the end of the current year and the previous year. Although generally defined as the ratio between operating income and average total assets, the literature on financial institutions commonly adopts net income in the numerator of ROA, as in Busch and Kick (2009), Moudud-Ul-Huq *et al*. (2018), Ngoc Nguyen (2019), and Williams (2016), who used both metrics (ROA and ROE), while Ferreira, Zanini, and Alves (2019), Köhler (2014), Meslier, Tacneng, and Tarazi (2014), and Vieira and Girão (2016) used only ROA, and DeYoung and Rice (2004) and Li and Zhang (2013) used only ROE.

For risk-adjusted returns, we employ the ratio of ROE and ROA to the standard deviation of these metrics over the period used in the sample.

$$RAR_{ROE_{it}} = \frac{ROE_{it}}{\sigma_{ROE_i}} \quad (3)$$

$$RAR_{ROA_{it}} = \frac{ROA_{it}}{\sigma_{ROA_i}} \quad (4)$$

Where RAR denotes the risk-adjusted return for each entity *i* in each period *t*, while σ is the standard deviation of ROE and ROA for each entity *i*, which is unique for the entire period. We employ Both metrics by Busch and Kick (2009), Chiorazzo, Milani, and Salvini (2008), Sanya and Wolfe

(2011), Sissy, Amidu, and Abor (2017), Stiroh (2004b), and Stiroh and Rumble (2006), while Ferreira, Zanini, and Alves (2019), Köhler (2014), and Meslier, Tacneng, and Tarazi (2014) studied only RAR_{ROA}.

We calculate the insolvency risk of the entities using the Z_{Score}, computed using the expression below.

$$Z_{Score_{it}} = \frac{ROA_{it} + \left(\frac{E}{A}\right)_{it}}{\sigma_{ROA_i}} \quad (5)$$

We note that the higher the Z_{Score}, the lower the entity's insolvency risk. Ferreira, Zanini, and Alves (2019), Köhler (2014), Lee, Hsieh, and Yang (2014), Li and Zhang (2013), Moudud-Ul-Huq *et al*. (2018), Ngoc Nguyen (2019), Saklain and Williams (2024), Sanya and Wolfe (2011), Sissy, Amidu, and Abor (2017), Stiroh (2004b), Stiroh and Rumble (2006), Vieira and Girão (2016), and Wang and Lin (2021), studied this metric.

Independent Variables

We construct three ratios to measure income diversification. As a basis, we adopt the Herfindahl-Hirschman Index (HHI), defined below, as used by Ferreira, Zanini, and Alves (2019), Ngoc Nguyen (2019), Sanya and Wolfe (2011), Sissy, Amidu, and Abor (2017), Stiroh (2004b), and Williams (2016). Busch and Kick (2009) also used the HHI, but the authors measured the diversification of banks' credit portfolios and net income.

$$HHI = \sum p_i^2 \quad (6)$$

Where HHI is the index and p is the probability of the event occurring or, in this study, the share of each type of income in the total, so that $0 \leq p_i \leq 1$ and the sum of the shares equals 1. Thus, the higher the index, the lower the diversification measured by it, as all income would be concentrated in a single type. To obtain a positive relationship (i.e., where an increase in the index denotes greater diversification), it can be adjusted as follows:

$$HHI_{Adjusted} = 1 - HHI \quad (7)$$

In this work, we adopt therefore, the adjusted Herfindahl-Hirschman Index, as in Chiorazzo, Milani, and Salvini (2008), Elsas, Hackethal, and Holzhäuser (2010), Lee, Hsieh, and Yang (2014), Saklain and Williams (2024), Stiroh and Rumble (2006), Vieira and Girão (2016), and Wang and Lin (2021), between others.

To measure income diversification we adopt a general index, which measures diversification between interest and non-interest income, an index for diversification within interest income, and another index to measure diversification within non-interest income.

We consider the totals of each type of income, their elements, and the aggregations made in the "Income Statement" Report of Bacen's IF.data. In the context of interest income, there is a column called "Financial Intermediation Income (a)" – which, in theory, would be the total of interest income – given by the sum of six other columns: "Credit Loans Income (a1)", "Leasing Operations Income (a2)", "Securities Operations Income (a3)", "Derivative Financial Instruments Operations Income (a4)", "Exchange Operations Result (a5)", and "Compulsory Applications Income (a6)". However, the columns "Derivative Financial Instruments Operations Income (a4)" and "Exchange Operations Result (a5)" were excluded from the calculation.

The column "Derivative Financial Instruments Operations Income (a4)" was excluded because, due to the way data aggregation was done in IF.data, there may be negative values for this type of income, which would distort the income diversification ratios. Negative values occur in more than 40% of the sample observations, justifying their exclusion.

The column "Exchange Operations Result (a5)" was excluded because it also an aggregation of data: if the entity made a profit from exchange operations, the result will appear in this column, but if the entity made a loss from exchange operations, the result will appear in the column "Exchange Operations Result (b4)" of the same name, but within "Financial Intermediation Expenses (b)", justifying its exclusion as it is not an income but a net result.

Moreover, both columns "Derivative Financial Instruments Operations Income (a4)" and "Exchange Operations Result (a5)" have an irrelevant share compared to the column "Financial Intermediation Income (a)", representing less than 2% of the total. The other interest income columns do not have elements with negative values, so they were all considered.

Regarding non-interest income, the columns "Provision of Services Income (d1)", "Bank Fees Income (d2)", and "Other Operating Income (d7)" were considered. The column "Net Participation Result (d6)" was not considered for the same reason the column "Exchange Operations Result (a5)" was excluded from the interest income calculation, i.e., it is a net result and not an income.

Thus, we define the income diversification ratios as described in the equations below.

$$HHI_{Adj_{Inc_{it}}} = 1 - \left[\left(\frac{INT_{it}}{INC_{it}}\right)^2 + \left(\frac{NON_{it}}{INC_{it}}\right)^2\right] \quad (8)$$

$$HHI_{Adj_{Int_{it}}} = 1 - \left[\left(\frac{CL_{it}}{INT_{it}}\right)^2 + \left(\frac{LEA_{it}}{INT_{it}}\right)^2 + \left(\frac{SEC_{it}}{INT_{it}}\right)^2 + \left(\frac{CAP_{it}}{INT_{it}}\right)^2\right] \quad (9)$$

$$HHI_{Adj_{Non_{it}}} = 1 - \left[\left(\frac{PSI_{it}}{NON_{it}}\right)^2 + \left(\frac{BFI_{it}}{NON_{it}}\right)^2 + \left(\frac{OTH_{it}}{NON_{it}}\right)^2\right] \quad (10)$$

Where HHI_{AdjInc} is the general income diversification index (ranging from 0 to 0.5), HHI_{AdjInt} is the interest income diversification index (ranging from 0 to 0.75), HHI_{AdjNon} is the non-interest income diversification index (ranging from 0 to 0.67), INT is the total interest income, NON is the total non-interest income, INC is the total operating income, CL are the credit loans, LEA is the leasing operations income, SEC is the securities operations income, CAP is the compulsory applications income, PSI is the service provision income, BFI is the bank fees income, and OTH is the other operating income of entity i in period t.

Control Variables

In addition to the variables already listed, control variables commonly adopted in the literature were also applied. Table 2 lists the variables used in the model, as well as the references of authors who included them in their work.

Table 2 - Control variables adopted in the model

Variable	Description	References
$(CL/A)_{it}$	The ratio between credit loans (given by account 1.6.0.00.00-1 of Cosif) and the total assets of entity i at the end of period t.	Baele, Jonghe and Vander Vennet (2007), Busch and Kick (2009), Chiorazzo, Milani and Salvini (2008), DeYoung and Rice (2004), Ferreira, Zanini and Alves (2019), Köhler (2014), Lee, Hsieh and Yang (2014), Meslier, Tacneng and Tarazi (2014), Ngoc Nguyen (2019), Saklain and Williams (2024), Sanya and Wolfe (2011), Stiroh (2004b), Stiroh and Rumble (2006), Vieira and Girão (2016), Wang and Lin (2021) and Williams (2016).; Nazaré (2020) uses it to study earnings management in banks.
$(LLP/A)_{it}$	The ratio between loan loss provisions (given by account 1.6.9.00.00-8 of Cosif) and the total assets of entity i at the end of period t	Ferreira, Zanini and Alves (2019) and Wang and Lin (2021).; Nazaré (2020) uses it as the dependent variable to study earnings management in banks. Other authors use similar metrics: Baele, Jonghe and Vander Vennet (2007) use the ratio between provisions and revenues; Busch and Kick (2009), Chiorazzo, Milani and Salvini (2008) and Scheriber (2024) use the ratio between loan loss provisions and credit loans.
$(E/A)_{it}$	The ratio between equity and total assets of entity i at the end of period t	Baele, Jonghe and Vander Vennet (2007), Busch and Kick (2009), Chiorazzo, Milani and Salvini (2008), Ferreira, Zanini and Alves (2019), Köhler (2014), Lee, Hsieh and Yang (2014), Meslier, Tacneng and Tarazi (2014), Moudud-Ul-Huq *et al.* (2018), Ngoc Nguyen (2019), Nguyen (2012), Saklain and Williams (2024), Sanya and Wolfe (2011), Sissy, Amidu and Abor (2017), Stiroh (2004a, 2004b), Stiroh and Rumble (2006), Vieira and Girão (2016) and Williams (2016).; Li and Zhang (2013), Moudud-Ul-Huq *et al.* (2018) and Nazaré (2020) use the ratio between liabilities and total assets.
$ln(A_{it})$	Natural logarithm of the total assets of entity i at the end of period t.	Baele, Jonghe and Vander Vennet (2007), Busch and Kick (2009), DeYoung and Rice (2004), Ferreira, Zanini and Alves (2019), Köhler (2014), Lee, Hsieh and Yang (2014), Li and Zhang (2013), Mehmood and De Luca (2023), Meslier, Tacneng and Tarazi (2014), Moudud-Ul-Huq *et al.* (2018), Ngoc Nguyen (2019), Nguyen (2012), Saklain and Williams (2024), Sanya and Wolfe (2011), Sissy, Amidu and Abor (2017), Stiroh (2004a, 2004b), Stiroh and Rumble (2006), Vieira and Girão (2016), Wang and Lin (2021) and Williams (2016).; Chiorazzo, Milani and Salvini (2008) use assets deflated by GDP.; Nazaré (2020) uses this to study earnings management in banks.
AG_{it}	Growth of entity i total assets from the end of period t to the end of period t-1	Ferreira, Zanini and Alves (2019), Lee, Hsieh and Yang (2014), Li and Zhang (2013), Mehmood and De Luca (2023), Meslier, Tacneng and Tarazi (2014), Moudud-Ul-Huq *et al.* (2018), Ngoc Nguyen (2019), Saklain and Williams (2024), Sanya and Wolfe (2011), Stiroh (2004a, 2004b) and Stiroh and Rumble (2006).; Busch and Kick (2009) and Chiorazzo, Milani and Salvini (2008) use the deflated indicator.; Vieira and Girão (2016) use the annual growth considering t-2 to t.

Source: Self elaboration.

The Model

The model used in this work, described below, is a multiple linear regression with balanced panel data, employing the Ordinary Least Squares (OLS) method with fixed effects, a technique also used by Busch and Kick (2009), Chiorazzo, Milani, and Salvini (2008), Stiroh and Rumble (2006), and Nazaré (2020). As Gujarati and Porter (2011) point out, panel data allow for better detection and measurement of effects that cannot be observed in cross-sectional or pure time series data, and, among other advantages, they will enable the study of more complex behavioral models. Furthermore, the authors continue that the fixed effects model considers the heterogeneity among entities, which does not eliminate potential problems with this type of modeling, which will be discussed later.

$$Y_{it} = \beta_1 HHI_{Adj_{Inc_{it}}} + \beta_2 HHI_{Adj_{Non_{it}}} + \beta_3 HHI_{Adj_{Int_{it}}} + \beta_4 \left(\frac{CL}{A}\right)_{it} + \beta_5 \left(\frac{LLP}{A}\right)_{it} + \beta_6 \left(\frac{E}{A}\right)_{it} + \beta_7 \ln(A_{it}) + \beta_8 AG_{it} + \alpha_t + \lambda_i + \varepsilon_{it} \quad (11)$$

Where Y_{it} represents the target variables ROA, ROE, RAR_{ROA}, RAR_{ROE}, and Z_{Score}, α_t is the fixed effect of time, λ_i is the fixed effect of banks, and ε_{it} represents the model error. Additionally, the Durbin-Watson test was applied to analyze the autocorrelation of residuals, also used by Nazaré (2020), so that if the p-value is more significant than 0.05, it can be stated that there is no autocorrelation of residuals.

RESULTS AND DISCUSSION

This section provides a brief description of the sample data, a presentation of the models' results, and a discussion of these results.

Data

Initially, the descriptive statistics of the model's variables are described in Table 3.

Table 3 - Descriptive statistics of the variables used in the model

Variable	Mean	Max.	3º Quartile	Median	1º Quartile	Min.	Std. Dev.
ROE	0.1614	0.4084	0.1981	0.1570	0.1182	-0.2446	0.0795
RAR_{ROE}	4.3297	12.2557	5.5843	3.5580	2.5206	-2.0809	2.9638
ROA	0.0138	0.0439	0.0172	0.0130	0.0084	-0.0166	0.0086
RAR_{ROA}	4.2413	11.8636	5.4726	3.4906	2.4594	-1.8114	2.7695
Z_{Score}	31.6851	102.9756	38.4714	25.9481	18.3639	5.4270	20.5275
HHI_{AdjInc}	0.3405	0.5000	0.4329	0.3541	0.2477	0.1064	0.1087
HHI_{AdjInt}	0.4384	0.6329	0.5139	0.4771	0.4089	0.0941	0.1179
HHI_{AdjNon}	0.5439	0.6643	0.5977	0.5584	0.5084	0.0698	0.0926
CL/A	0.3548	0.7427	0.4725	0.3449	0.2409	0.0762	0.1622
LLP/A	0.0197	0.0413	0.0280	0.0225	0.0126	0.0008	0.0102
E/A	0.0862	0.1930	0.1042	0.0905	0.0651	0.0216	0.0317
ln(A)	18.5909	21.4113	20.5036	18.4004	17.2073	15.1315	1.7542
AG	0.1284	1.8969	0.1962	0.1075	0.0389	-0.4539	0.1935

Source: Self elaboration.

Following this, we create a correlation matrix to observe the multicollinearity of the independent variables. Gujarati and Porter (2011) suggest that if the correlation between two regressors is high (greater than 0.8), multicollinearity will be a serious problem. As can be seen in Table 4, the highest coefficient found was 0.70, so we decided to keep all initially proposed variables.

Table 4 - Correlation between the independent variables used in the model

	HHI_{AdjInc}	HHI_{AdjInt}	HHI_{AdjNon}	CL/A	LLP/A	E/A	ln(A)	AG
HHI_{AdjInc}	1							
HHI_{AdjInt}	0.3829	1						
HHI_{AdjNon}	0.0628	0.0640	1					
CL/A	-0.6018	-0.4597	0.1535	1				
LLP/A	-0.3051	-0.0844	0.4759	0.7002	1			
E/A	0.0839	-0.3676	0.1926	-0.0101	0.0601	1		
ln(A)	0.3725	0.4859	0.3849	-0.0469	0.2601	-0.3224	1	
AG	0.0513	-0.1410	-0.1330	-0.0826	-0.2489	-0.1712	-0.1006	1

Source: Self elaboration

Models

The initial models tested were for the profitability of the companies through ROE and ROA; the observed results are in Table 5 and Table 6. In both models, there is no statistical significance for the coefficients of the diversification variables. Additionally, the Durbin-Watson test indicated the presence of autocorrelation in the residuals in the ROA model, which did not occur in the ROE model.

Table 5 - ROE Model Results

Variable	Coefficient	Standard Error	p-value
HHI_{AdjInc}	-0.0158	0.1234	0.8985
HHI_{AdjInt}	0.0537	0.1018	0.5990
HHI_{AdjNon}	0.1046	0.0915	0.2551
CL/A	-0.0129	0.1163	0.9116
LLP/A	-2.1973	1.2238	0.0749
E/A	-0.5022	0.4377	0.2534
ln(A)	-0.1371	0.0420	0.0014
AG	0.1344	0.0344	0.0001
Statistics			
R^2	0.6385	R^2 Within	0.1984
F Test	3.9278	p-value	0.0004
Durbin-Watson Test	1.7720	p-value (DW)	0.0545

Source: Self elaboration.

Table 6 - ROA Model Results

Variable	Coefficient	Standard Error	p-value
HHI_{AdjInc}	0.0031	0.0099	0.7517
HHI_{AdjInt}	0.0009	0.0082	0.9167
HHI_{AdjNon}	0.0076	0.0073	0.3041
CL/A	-0.0036	0.0093	0.7032
LLP/A	-0.2452	0.0982	0.0138
E/A	0.0649	0.0351	0.0669
ln(A)	-0.0110	0.0034	0.0014
AG	0.0119	0.0028	0.0000
Statistics			
R^2	0.7990	R^2 Within	0.2423
F Test	5.0767	p-value	0.0000
Durbin-Watson Test	1.5677	p-value (DW)	0.0019

Source: Self elaboration.

The results of the models studying risk-adjusted profitability, RAR_{ROE} and RAR_{ROA}, are found in Table 7 and 8, respectively. Here, a negative relationship between RAR_{ROE} and the general income diversification index is observed, with this relationship being statistically significant. The other income diversification ratios in both models are not statistically significant, Both models' other income diversification ratios are not statistically relevant, given p-values above 5%. It is important to note that the Durbin-Watson test did not indicate autocorrelation in the residuals of the RAR_{ROE} model, which brings greater confidence in the model's results.

Table 7 - RAR_{ROE} Model Results

Variable	Coefficient	Standard Error	p-value
HHI_{AdjInc}	-4.2578	2.076	0.0424
HHI_{AdjInt}	0.5757	1.713	0.7373
HHI_{AdjNon}	1.315	1.540	0.3948
CL/A	-0.3455	1.9572	0.8602
LLP/A	-51.3132	20.5894	0.0140
E/A	-8.6676	7.3639	0.2414
ln(A)	-1.2180	0.7074	0.0876
AG	1.5644	0.5782	0.0078
Statistics			
R^2	0.9263	R^2 Within	0.1983
F Test	3.9258	p-value	0.0004
Durbin-Watson Test	1.7873	p-value (DW)	0.0661

Source: Self elaboration.

Table 8 - RAR_{ROA} Model Results

Variable	Coefficient	Standard Error	p-value
HHI_{AdjInc}	-0.7144	2.0192	0.7241
HHI_{AdjInt}	1.0463	1.6655	0.5310
HHI_{AdjNon}	1.6775	1.4972	0.2646
CL/A	0.9173	1.9033	0.6307
LLP/A	-56.5766	20.0226	0.0055
E/A	11.9681	7.1611	0.0971
ln(A)	-1.7724	0.6879	0.0111
AG	2.0925	0.5623	0.0003
Statistics			
R^2	0.9202	**R^2 Within**	0.2054
F Test	4.1043	**p-value**	0.0002
Durbin-Watson Test	1.5417	**p-value (DW)**	0.0011

Source: Self elaboration.

Finally, Table 9 shows the results of the model testing the. Similarly to the other models, there was no statistical significance for the income diversification variables, and the Durbin-Watson test indicated the presence of autocorrelation in the residuals.

Table 9 - Z_{Score} Model Results

Variable	Coefficient	Standard Error	p-value
HHI_{AdjInc}	8.2606	6.2756	0.1904
HHI_{AdjInt}	5.4482	5.1762	0.2946
HHI_{AdjNon}	2.2071	4.6531	0.6361
CL/A	9.9625	5.9155	0.0946
LLP/A	1.6917	62.2297	0.9784
E/A	203.3471	22.2564	0.0000
ln(A)	-4.6390	2.1380	0.0319
AG	2.4969	1.7475	0.1555
Statistics			
R^2	0.9860	**R^2 Within**	0.6298
F Test	27.0095	**p-value**	0.0000
Durbin-Watson Test	1.4788	**p-value (DW)**	0.0003

Source: Self elaboration.

Discussion

In general, no statistically significant relationship was found between bank income diversification and the profitability and risk of banks. However, there was a negative relationship between the general diversification index (between interest and non-interest income groups) and risk-adjusted profitability measured by RAR_{ROE}.

Additionally, the ROA, RAR_{ROA}, and Z_{Score} models showed autocorrelation in the residuals and, after estimating the coefficients, tests were conducted to verify the presence of heteroscedasticity in the model residuals, confirmed in all models except ROE model. Gujarati and Porter (2011) warn that although estimators retain the characteristic of unbiasedness in the presence of autocorrelation and heteroscedasticity, they cease to be efficient, which can lead to misleading conclusions about the statistical significance of the estimated regression coefficients. Thus, despite detecting a relationship

with a p-value below 5% in the RAR_{ROE} model with general income diversification, this may not be the real statistical significance of the result.

In the ROE model, however, no autocorrelation or heteroscedasticity in the residuals was detected, suggesting no significant impact of bank income diversification on bank profitability measured by ROE in the sample. Thus, it was impossible to confirm that bank income diversification, both between interest and non-interest income and within each of these groups, impacts financial institutions' profitability, insolvency risk, and risk-adjusted return.

Gujarati and Porter (2011) indicate that, in the presence of autocorrelation and heteroscedasticity, a generalized least squares model can be used, such as the feasible generalized least squares (FGLS) method adopted by Williams (2016). However, Gujarati and Porter (2011) warn that the properties of this model need to be better documented for small samples, indicating that it may be worse than the OLS method in this case.

Ferreira, Zanini, and Alves (2019), Lee, Hsieh, and Yang (2014), Meslier, Tacneng, and Tarazi (2014), Moudud-Ul-Huq *et al*. (2020), Ngoc Nguyen (2019), Nguyen (2012), Sanya and Wolfe (2011), Sissy, Amidu, and Abor (2017), Vieira and Girão (2016), and Wang and Lin (2021) used another type of model to study bank income diversification: the generalized method of moments (GMM) with dynamic panel data. However, Williams (2016) argues that this method is optimized for samples with a large number of entities and a relatively short period, leading the author to opt for FGLS in his work.

FINAL REMARKS

This work aimed to contribute to the literature on the impact of bank income diversification on the profitability (measured by ROE and ROA), insolvency risk (measured by Z_{Score}), and risk-adjusted profitability (measured by RAR_{ROE} and RAR_{ROA}) of Brazilian banks. A sample with data from 16 Brazilian banks, 8 state-owned and 8 private, was used from 2012 to 2021.

To investigate this impact, we use a fixed-effects linear regression model, considering both the fixed effect of the banking entities and the fixed effect of time. Additionally, tests were applied to detect the presence of autocorrelation and heteroscedasticity in the model residuals.

We did not find statistically significant coefficients in the five models used to prove the impact of diversification within interest income and diversification within non-interest income on the studied variables.

For RAR_{ROE}, a negative relationship was found between the general income diversification index (which measures diversification between the two income groups, interest and non-interest) and risk-

adjusted profitability with apparent statistical significance; however, the presence of heteroscedasticity in the model residuals may indicate that the statistical significance of the coefficient found is overestimated, i.e., the result may not be statistically significant.

Therefore, although the literature suggests that income diversification contributes to risk reduction, increased profitability, and improved risk-adjusted returns, our statistical analysis does not provide significant evidence to support these associations. Sample limitations may explain this outcome, highlighting the need for further research to assess this relationship.

Possible improvements to this work would be expanding the sample size by increasing the number of observed entities and, eventually, extending the period and using other statistical models, such as the feasible generalized least squares method (FGLS) and the generalized method of moments (GMM), we would optimize with the use of a sample with more observations.

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