

Asset liability management in credit unions: Evidence from Brazil

Flávia Zancan¹

 <https://orcid.org/0000-0002-5060-7615>

Email: flaviazancan@alumni.usp.br

Marcelo Botelho da Costa Moraes¹

 <https://orcid.org/0000-0003-0761-0883>

Email: mbotelho@usp.br

¹Universidade de São Paulo, Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto, Departamento de Contabilidade, Ribeirão Preto, SP, Brazil

Received on 05/03/2024 – Desk acceptance on 05/21/2024 – 3rd version approved on 11/21/2024

Editor-in-Chief: Andson Braga de Aguiar

Associate Editor: Cláudio de Araújo Wanderley

ABSTRACT

This study aims to analyze the matching of discretionary asset and liability accounts in Brazilian credit unions and their evolution over time. Asset liability management for discretionary accounts and their evolution over time have not been addressed in previous studies, which have mainly focused on standardized account balances to analyze financial institutions, but not all Brazilian individual credit unions. The findings are particularly relevant to academia, managers and banking regulators by providing insights into discretionary account management. They contribute to a deeper and more practical understanding of asset liability management in the national context, with findings on the positive evolution over time, size and periods of economic crisis. The study can positively impact the efficient management of credit unions, minimizing financial risks and promoting financial inclusion in communities where these institutions play a significant role. Canonical correlation was used in the management of seven asset accounts and nine liability accounts to evaluate 672 Brazilian individual credit unions, from 2014 to 2022, totaling 5,361 observations. Asset liability management occurs, on average, in twenty percent of credit union discretionary accounts, allowing for their active management. A positive trend was observed in the dependence of these accounts over time. When analyzing the influence of size, greater dependence of the accounts was found in smaller credit unions. During periods of economic crisis, differences in management were more evident, and it is possible that managers adopted more efficient strategies during these periods.

Keywords: capital structure, credit unions, canonical correlation.

Correspondence address

Flávia Zancan

Universidade de São Paulo, Faculdade de Economia,
Administração e Contabilidade de Ribeirão Preto, Departamento de Contabilidade
Avenida Bandeirantes, 3900 – CEP: 14040-905
Monte Alegre – Ribeirão Preto – SP – Brazil

This is a bilingual text. This article was originally written in Portuguese, published under the DOI [10.1590/1808-057x20242151.pt](https://doi.org/10.1590/1808-057x20242151.pt)

This article stems from a Ph.D. thesis submitted by the co-author Flávia Zancan, in 2025.

Study presented at the 24th USP International Conference on Accounting and at the 21st Congresso USP de Iniciação Científica em Contabilidade, São Paulo, SP, Brazil, July 2024.



Gestão de ativos e passivos em cooperativas de crédito: evidências para o Brasil

RESUMO

Este estudo tem como objetivo analisar o casamento das contas discricionárias de ativos e passivos nas cooperativas de crédito brasileiras e sua evolução ao longo do tempo. A gestão de ativos e passivos para contas discricionárias e sua evolução ao longo do tempo não foram abordadas em estudos anteriores, que se concentraram principalmente em saldos de contas padronizados para analisar instituições financeiras, mas não todas cooperativas de crédito singulares brasileiras. As descobertas são particularmente relevantes para a academia, gestores e reguladores bancários ao fornecer insights sobre a gestão em contas discricionárias. Contribuindo para uma compreensão mais profunda e prática da gestão dos ativos e passivos no contexto nacional, com descobertas quanto à evolução positiva ao longo do tempo, porte e períodos de crises econômicas. O estudo pode impactar positivamente a gestão eficiente das cooperativas de crédito, minimizando riscos financeiros e promovendo a inclusão financeira em comunidades onde essas instituições desempenham um papel significativo. Foi utilizada correlação canônica na gestão de sete contas de ativos e nove contas de passivos, para avaliar 672 cooperativas de crédito singulares brasileiras, no período de 2014 a 2022, totalizando 5.361 observações. A gestão de ativos e passivos ocorre em média a vinte por cento das contas discricionárias nas cooperativas de crédito, permitindo seu gerenciamento ativo. Observou-se uma evolução positiva na dependência dessas contas ao longo do tempo. Ao analisar a influência do tamanho, identificou-se uma maior dependência das contas em cooperativas de crédito de menor porte. Durante períodos de crises econômicas, as diferenças na gestão foram mais evidentes, sendo possível que os gestores tenham adotado estratégias mais eficientes nesses períodos.

Palavras-chave: estrutura de capital, cooperativas de crédito, correlação canônica.

1 INTRODUCTION

Credit unions' decisions about the services they provide and the funds they raise and invest are guided by their business models, which are reflected in their financial statements (Stowe & Stowe, 2018). Over time, the banking business model has become more sophisticated, and success is dependent on the quality of asset liability management (ALM).

ALM is concerned with the simultaneous management of both sides of a financial institution's balance sheet, identifying the key relationships between its elements in order to manage risk (DeYoung & Yom 2008; Owusu & Alhassan, 2021). This makes it possible to infer which asset accounts financial institutions are likely to associate with which liability accounts in their capital structure, reflecting an important part of modern financial theory (Stowe et al., 1980). However, some accounts do not qualify as ALM instruments because they have a specific purpose (Fantin & Kondo, 2015). The focus of this study is on discretionary accounts that are actively managed by credit unions.

Changes in business models, regulatory changes, and new risk transfer instruments can give financial institutions room for maneuver in ALM. It is therefore important to analyze the evolution of this management over time, as discussed by DeYoung and Yom (2008) and Memmel and Schertler (2012).

From this perspective, we seek to answer the following question: How does the matching of discretionary asset

and liability accounts occur in Brazilian credit unions and how has it evolved over time? Therefore, this study aims to analyze the matching of discretionary asset and liability accounts in Brazilian credit unions and its evolution over time. The ALM of discretionary accounts from 2014 to 2022 was considered. For this purpose, canonical correlations tested in the banking sector were used (Fraser et al., 1974; Simonson et al., 1983; DeYoung & Yom, 2008; Memmel & Schertler, 2012; Abou-El-Sood & El-Ansary, 2017).

While several studies have examined ALM in developed economies (Francis, 1978; Simonson et al., 1983; DeYoung & Yom, 2008; Memmel & Schertler, 2012; Lysiak et al., 2022), empirical evidence from emerging economies seems scarce (Abou-El-Sood & El-Ansary, 2017; Owusu & Alhassan, 2021), especially in Brazil (Alves & Moreira, 1996; Leão et al., 2012; Bittencourt & Bressan, 2016). Although economists and the public have a strong interest in financial intermediaries, general knowledge about credit unions is still in its infancy (Stowe & Stowe, 2018).

Credit unions are financial institutions organized as cooperatives. Internationally, credit unions are well established. In 2018, there were 2,816 cooperative banks in the European countries where they originated, operating 51,588 branches, employing 712,700 people and holding 712.7 billion euros in assets (McKillop et al., 2020). They also play an important role in financing small and medium-sized enterprises in Finland, France, Germany

and the Netherlands, while they have a significant share of the national banking market in Austria, Denmark, Finland, France, Germany, Luxembourg and the Netherlands (McKillop et al., 2020). In Brazil, cooperativism has developed significantly (Bressan et al., 2017), offering financial services at lower costs than those charged by the banking system (Bittencourt et al., 2017). According to the Panorama of the National Cooperative Credit System (SNCC) (BCB, 2022), between 2018 and 2022, the presence of credit unions in Brazilian municipalities increased from 47.3% to 55.3%. In the same period, the number of municipalities served by the traditional banking segment decreased. In 2022 alone, 174 new municipalities began to be served by credit unions, while 85 municipalities ceased to be served by bank branches and offices. In 2022, there were 799 credit unions serving 15.6 million members, with growth above the rest of the National Financial System (BCB, 2022).

Among the findings of this study, statistically significant evidence was obtained that there was a positive trend in the dependence of asset and liability accounts over time, which differed from the international banking context (DeYoung & Yom, 2008; Memmel & Schertler, 2012). This dependence was greater for smaller credit unions, and more efficient ALM strategies tended to be adopted during economic crises.

This study offers potential theoretical, practical and social contributions. With regard to theoretical aspects, although Alves and Moreira (1996), Leão et al. (2012) and Bittencourt and Bressan (2016) have analyzed ALM in financial institutions, these analyses do not include all

individual credit unions and no national studies with this focus were identified. Although they represent a promising sector, there is still a need to explore the management of discretionary asset and liability accounts and their evolution over time, so that new insights can be developed, as is the case in the international literature (DeYoung & Yom, 2008; Memmel & Schertler, 2012). From a practical perspective, good asset and liability management can minimize the risk of credit unions going out of business, reducing the negative impact on their members and the broader economy (Carvalho et al., 2015). It can also help managers and regulators of institutions to implement the “processes, controls and specific actions” used for ALM (Fantin & Kondo, 2015, p. 79). This is fundamental for the appropriate allocation of capital and human resources to value-creating activities and for the risk control process (Dermine, 2012). Factors such as the cost, complexity of the process, and differences in management needs mean that not all credit unions adopt ALM with the same rigor. The absence of ALM can lead to problems such as excessive exposure to interest rate risk and inefficiencies in balance sheet management. Alternatives to ALM, such as interest rate derivatives, asset securitization, and adjustable rate loans, make it possible to manage this risk and reduce the associated costs (DeYoung & Yom 2008; Memmel & Schertler, 2012). In terms of social aspects, credit unions are important because of the role they play with their members and the community (Gollo & Silva, 2015). These unions are also considered important agents of financial inclusion because they operate in regions where traditional banks are not interested (BCB, 2022).

2 THEORETICAL FRAMEWORK

This section first reviews the literature on ALM in financial institutions. It then presents the study's hypotheses regarding the positive evolution of ALM over time, size and periods of economic crisis.

2.1 Empirical Literature on Asset Liability Management in Financial Institutions

A credit union's business model defines how it invests its assets, collects funds and manages operations. The focus of ALM is on liquidity risk, which ensures that deposits are met and operational stability is maintained.

Empirical research on ALM in financial institutions was initiated by Fraser et al. (1974). They used canonical correlation to measure the degree of correlation and integration between the dependent and independent variables, from 1969 to 1970. They identified bank costs,

deposits and loans, which were under the control of Texas bank management, as determinants of performance.

Since then, studies have examined the dependence in asset-liability relationships proposed by Simonson et al. (1983) for large US banks at the end of 1979, which supports the interdependence of asset and liability portfolio choices. DeYoung and Yom (2008), focusing on US commercial banks from 1990 to 2005, found evidence that assets and liabilities became more independent over time for large banks, but not for small banks. In addition, Memmel and Schertler (2012) examined the dependence relationship between assets and liabilities for three sectors of German universal banks (commercial, savings and cooperative banks) from 1994 to 2007 and found a decrease in dependence over this period.

ALM and the ability of American banks of different sizes to manage their asset and liability portfolios between

1966 and 1971 were analyzed by Francis (1978). Large banks had better ALM and a higher return on assets, although they paid higher interest rates on their liabilities.

In addition, the issue of ALM in times of crisis was addressed by Tektas et al. (2005), who analyzed ALM in Turkish commercial banks from 1999 to 2000, focusing on how different management strategies affect financial well-being during crises. The proposed model enables effective forecasting of assets, liabilities and financial position, which helps to make contingency plans and provides a competitive advantage to decision makers in different economic scenarios. Abou-El-Sood and El-Ansary (2017) analyzed the interdependences between asset and liability portfolio choices in Islamic banks from 2002 to 2012, driven by bank failures during the financial crisis. They found that the ratio of assets to liabilities varied between the crisis and post-crisis periods.

In the context of emerging markets, Owusu and Alhassan (2021) examined the relationship between ALM and profitability in Ghanaian banks from 2007 to 2015. They found that profitability is related to balance sheet items, making it possible to identify which assets and liabilities generate the highest return. In Brazil, the literature on ALM in financial institutions is limited. Alves and Moreira (1996) innovated by extending the analysis of interest rate risk management, presenting useful tools for the managers of these institutions. Leão et al. (2012) performed an ALM analysis focusing on market and liquidity risks, evaluating the results of the Minas Gerais Development Bank S/A during periods of stress. Bittencourt and Bressan (2016) studied the relationship between the assets and liabilities of credit unions in the Sicredi system and found a conservative stance, with most assets financed by equity, indicating a reduction in leverage. However, these studies do not address ALM in all Brazilian individual credit unions, and no other national studies with this focus were identified.

2.2 Hypothesis Development

DeYoung and Yom (2008) look at the evolution of the asset-liability relationship over time, suggesting that the introduction of new risk management tools has reduced the need for strict ALM based on maturity or duration matching to control interest rate risk in US banks. Memmel and Schertler (2012) also test this hypothesis for Germany, showing that the dependence between assets and liabilities has decreased over time.

In the context of Brazilian credit unions, they differ from traditional banks by focusing on financial intermediation with the aim of raising and allocating funds according

to the needs of the community, taking into account the role they play with their members (Gollo & Silva, 2015; Bittencourt et al., 2017). This dynamic can promote greater synergy between assets and liabilities, leading to improvements in risk management. The implementation of new regulations and governance practices, such as the Basel III capital requirements, liquidity management, and transparency in operations, may have increased awareness of the importance of efficient management. This may lead to increased dependence between discretionary accounts over time. Thus, the first hypothesis (H1) can be stated as follows:

H1: There is a positive trend over time in the dependence of discretionary asset and liability accounts in credit unions.

The size of the financial institution is a factor that should be considered when determining ALM (Francis, 1978; DeYoung & Yom, 2008; Memmel & Schertler, 2012; Abou-El-Sood & El-Ansary, 2017). According to Francis (1978), smaller banks have a local geographic focus that leads to inflexibility in the deposit mix and granularity in individual loans, which limits balance sheet ALM. DeYoung and Yom (2008) find that small banks are less able to engage in ALM than large banks. Higher asset-liability ratios can also be expected in small banks, which have less access to risk mitigation instruments such as derivatives. These banks must manage interest rate risk directly on their balance sheets, resulting in stronger correlations between maturities and account composition. Small credit unions face limited access to risk management instruments, which may result in a more rigid approach to interest rate management, increasing the correlation between maturities and the structure of assets and liabilities (Dermine, 2012), especially given their simpler and more integrated financial structure. Therefore, the second hypothesis (H2) can be stated as follows:

H2: Discretionary asset and liability account dependence is greater in small credit unions.

The importance of the banking sector within the financial system becomes even more evident in emerging markets, which are highly vulnerable to economic disruptions (Tektas et al., 2005), especially during periods of economic crisis. Structural differences in emerging markets create currency and maturity mismatch risks, so bank managers need to consider a wide range of scenarios and manage their balance sheets optimally by developing an efficient ALM strategy (Tektas et al., 2005). Abou-El-Sood and El-Ansary (2017) found that the dependences between banks' asset and liability portfolios are different

with respect to crisis and post-crisis periods. Therefore, it is relevant to examine whether the dependence between discretionary accounts has changed for credit unions in periods of economic crisis, as such periods may show greater resilience. Periods of economic crisis, characterized by negative fluctuations in gross domestic product (GDP)

(Iatridis & Dimitras, 2013; Filip & Raffounier, 2014), occurred in Brazil in 2015 (-3.545), 2016 (-3.275) and 2020 (-3.276). Therefore, the third hypothesis (H3) can be stated as follows:

H3: Discretionary asset and liability account dependence is greater during periods of economic crisis in credit unions.

3 METHOD

3.1 Data and Sample

The data come from the financial statements of all individual credit unions available on the BCB website, with values updated to December 2022 using the General Market Price Index (IGP-M). The data were collected in December of each year from 2014 to 2022, with the analysis starting in 2014 due to the implementation of the Basel III standards. It was decided to exclude the credit unions with data for only three years, those whose asset or liability position exceeded total assets, and credit unions classified as loan capital, as they do not have current account and deposit transactions. A total of 5,361 observations from 672 credit unions were analyzed.

3.2 Econometric Model and Variables

The canonical correlation technique was used as the basis for the analysis, following DeYoung and Yom (2008), who describe this methodology. The asset variables are represented by $X = [X_1, X_2 \dots X_p]$ and the liability variables are represented by $Y = [Y_1, Y_2 \dots Y_p]$, expressed as a proportion of the credit unions' total assets. Based on these variables, "linear combinations of X and Y " are created (DeYoung & Yom, 2008, p. 281):

$$A = B'X = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_p X_p \quad 1$$

$$L = C'Y = \gamma_1 Y_1 + \gamma_2 Y_2 + \gamma_3 Y_3 + \dots + \gamma_q Y_q \quad 2$$

where $B' = [\beta_1, \beta_2 \dots \beta_p]$, and $C' = [\gamma_1, \gamma_2, \dots, \gamma_p]$ are vectors of parameters to be estimated. The parameters that make up the vectors B' and C' are the canonical coefficients, and the

linear combinations A and L are called canonical variables (DeYoung & Yom, 2008). The canonical coefficients are defined to "maximize the canonical correlation between the canonical variables A and L " (DeYoung & Yom, 2008, p. 281):

$$r_{AL} = \frac{\sum a_l}{\sqrt{(\sum a^2)(\sum l^2)}} \quad 3$$

where a and l represent average differences for variables A and L . With $p \geq q$, there are up to p ways to combine asset and liability variables (DeYoung & Yom, 2008). The maximization process generates $p - 1$ different canonical correlations based on $p - 1$ linear and orthogonal combinations between A and L . The process results in $p - 1$ canonical correlations instead of p because one asset and one liability variable are ignored to avoid a singularity problem in the maximization. Bartlett's F-test (1947) was used to assess the statistical significance of these $p - 1$ canonical correlations.

The size and strength of the canonical correlation helps to identify relationships between certain asset and liability accounts. For example, a strong correlation between term deposits and the canonical variable L , and between credit operations and the canonical variable A , indicates that high levels of term deposits are associated with large amounts of credit operations, as long as the correlation r_{AL} is strong. Both share a common factor r_{AL} (DeYoung & Yom, 2008).

In credit unions, the relationships between assets and liabilities can be analyzed using canonical loadings, which measure the correlations between real variables and their canonical variables (DeYoung & Yom, 2008). For example, a "canonical loading X_1 with the first canonical variable A_1 is the correlation between X_1 and A_1 " (DeYoung & Yom, 2008, p. 282):

$$\text{Corr}(X_1, A_1) = \text{Corr} \left(X_1, \beta_1^1 X_1 + \beta_2^1 X_2 + \dots + \beta_p^1 X_p \right) = \beta_1^1 \sigma_{x,11} + \beta_2^1 \sigma_{x,12} + \dots + \beta_p^1 \sigma_{x,1p} \quad 4$$

The first canonical coefficients are $f \beta^1_p, \beta^2_p, \dots, \beta^i_p$, for A_p , $\sigma_{x,11}$ is the standard deviation of X_1 , $\sigma_{x,12}$ is the correlation between X_1 and X_2 , and so on (DeYoung & Yom, 2008). Similarly, canonical loadings can be calculated for liability variables (e.g., $Corr(Y_p, L_1)$) or for higher order ($p > 1$) canonical variables (e.g., $Corr(X_p, A_3)$). If the canonical correlation (3) between assets and liabilities is strong and the canonical loading (4) for asset i and liability k is strong, a relationship between asset i and liability k can be inferred. Canonical loadings also help determine the “proportion of the variance in the data that is explained by the canonical variables” (DeYoung & Yom, 2008, p. 282):

$$R^2_{A,j} = \sum_{i=1}^p \frac{(Corr(X_i, A_j))^2}{p} \quad 5$$

where $R^2_{A,j}$ represents the proportion of variance in the asset variables that is explained by the canonical variable of asset j ($j = 1, \dots, p$) (DeYoung & Yom, 2008). This measure indicates the effectiveness of the canonical variable in capturing the variance in the X variables. If only one asset variable is strongly associated with the canonical variable, $R^2_{A,j}$ tends to be low. The canonical correlation in (3) reflects the variance shared between linear combinations of asset and liability variables, not between the original variables. Thus, a high canonical correlation may result from a strong correlation between only one asset variable and one liability variable, potentially overestimating the true relationship. The redundancy coefficient assesses the “average ability of the asset (liability) variables to explain the variation in the liability (asset) variables considered individually” (DeYoung & Yom, 2008, p. 282):

$$R^2_{A|L,j} = u_j^2 R^2_{A,j} \quad 6$$

The term u_j^2 is the quadratic canonical correlation of j and reflects the proportion of variance in the canonical variable of asset j that is predictable from the canonical variable of liability j (DeYoung & Yom, 2008). The term $R^2_{A,j}$ indicates the proportion of variance in the asset that is explained by the j th canonical variable. The product of these two terms evaluates the proportion of asset variance explained by the j th canonical liability variable. The sum of the redundancy coefficients for all the canonical correlations yields $R^2_{A|L}$, which indicates the proportion of variance or redundancy of the asset variables that is explained by the liability variables.

The variables were divided into 16 accounts, 7 of which were classified as assets (dependent variables) and 9 as liabilities (independent variables), as shown in Table 1. The selection of the accounts was based on studies in the banking sector (Simonson et al., 1983; DeYoung & Yom, 2008; Memmel & Schertler, 2012; Abou-El-Sood & El-Ansary, 2017). Using the study by Fantin and Kondo (2015), it was possible to filter out the discretionary accounts that qualify as ALM instruments. The accounts were adjusted for credit unions, considering only those available on the Central Bank of Brazil (BACEN) website. It should be noted that there is no single method for dividing the right and left sides of the balance sheet before applying the canonical correlation (DeYoung & Yom, 2008).

According to Fávero and Belfiore (2024), the main multivariate statistical tests that assess the significance of canonical dimensions using the F statistic are Wilks' Lambda, Pillai's Trace, and Lawley-Hotelling Trace.

The hypotheses (H_0) of the tests state that the two vectors of variables are not linearly related, i.e., that the canonical correlations are statistically equal to zero at a given level of significance.

4 RESULTS AND DISCUSSION

This section presents the descriptive statistics of the discretionary accounts of 672 Brazilian credit unions, discusses the evolution over time, the impact of size, and analyzes the periods of economic crises and their absence.

4.1 Descriptive Statistics

The discretionary accounts were winsorized at 1% to eliminate extreme values and erroneous data identified in the histograms. Table 2 shows each account expressed

as a percentage of total assets (DeYoung & Yom, 2008; Memmel & Schertle, 2012).

During the period analyzed, ALM was applied, on average, to 25% of discretionary asset accounts and 23% of discretionary liability accounts, i.e., those that can be actively managed. Credit unions have direct control or the freedom to adjust these accounts, such as cash accounts, where financial resources are available, demand deposit accounts, which are “freely movable” (Fantin & Kondo, 2015, p. 50), and shareholders' equity, which is divided

Table 1
Study variables

Asset items	Code	Description – BCB Normative Instruction n. 268/2022
X_1 : Cash (cash)	1.1.1.00.00-9 (Available funds)	Its function is to record existing cash in national currency.
X_2 : Bank deposits (bank_dep)	1.1.2.00.00-2 (Available funds)	Their function is to record the value of demand deposits held in banks.
X_3 : Interbank deposit investments (dep_inv)	1.2.2.00.00-1 (Interbank liquidity investments)	Their function is to record investments made in other financial institutions.
X_4 : Free (free)	1.3.1.00.00-7 (Securities and derivative financial instruments)	Their function is to record securities not linked to transactions.
X_5 : Interbank relations (inter_rel)	1.4.0.00.00-3 (Interbank relations)	Their function is to record credits resulting from the transfer of funds to other financial institutions.
X_6 : Credit operations (cred_op)	1.6.0.00.00-1 (Credit operations)	Their function is to record credit operations that are not linked to the acquisition of goods or services or with no specific purpose for the use of the funds.
X_7 : Other assets (oth_assets)	(Other financial assets)	All other asset accounts not described.
Liability and equity items	Code	Description – BCB Normative Instruction no. 271/2022
Y_1 : Demand deposits (dem_dep)	4.1.1.00.00-0 (Deposits)	Their function is to record demand deposits.
Y_2 : Interbank deposits (inter_dep)	4.1.3.00.00-6 (Deposits)	Their function is to record funds received in deposits from other market institutions.
Y_3 : Term deposits (term_dep)	4.1.5.00.00-2 (Deposits)	Their function is to record deposits subject to defined terms and charges, with or without the issue of a bank deposit certificate.
Y_4 : Funds from foreign exchange acceptances, real estate and mortgage bills, debentures and similar (fund_acc)	4.3.0.00.00-5 (Funds from foreign exchange acceptances, real estate and mortgage bills, debentures and similar)	Their function is to record the funds arising from obligations represented by debentures issued by the institution, placed and to be placed on the market.
Y_5 : Interbank onlending (inter_on)	4.4.3.00.00-3 (Interbank relations)	Their function is to record obligations arising from funds obtained from financial institutions for onlending.
Y_6 : Interdependence relationships (inter_rel)	4.5.0.00.00-3 (Interdependence relationships)	Their function is to record interdependences in funds in transit from third parties and internal transfers of funds.
Y_7 : Loan obligations (loan_obl)	4.6.0.00.00-2 (Borrowings and onlending)	Their function is to record obligations for loans and onlending at home or abroad.
Y_8 : Shareholders' equity (share_eq)	6.0.0.00.00-2 (Shareholders' equity)	Their function is to record the institution's equity.
Y_9 : Other liabilities (oth_liab)	(Other financial liabilities)	All other liability accounts not described.

Source: Prepared by the authors.

into shares and can be increased through payments or decreased through the redemption of shares. An increase through the payment of profits is also possible.

On the other hand, on average, 75% of asset accounts and 77% of liability accounts may not allow direct management and the “ALM area cannot use them freely” (DeYoung & Yom, 2008; Fantin & Kondo, 2015, p. 55). The savings account is an example of funding with a mandatory destination (Fantin & Kondo, 2015).

The comparative analysis of asset and liability positions shows that there were few fluctuations in values over time. Credit unions have the highest asset balances in credit operations, which grew more than the rest of the National Financial System between 2018 and 2022 (BCB, 2022). The lowest asset balances were found in bank deposits, cash and investments in interbank deposits. The highest liability balance was found in term deposits, representing 48% of total funding in 2022 (BCB, 2022), while the

Table 2*Accounts expressed as a percentage of total assets (2014-2022)*

		2014	2015	2016	2017	2018	2019	2020	2021	2022
Asset accounts (%)	X_1 : cash	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%	0.000%	0.000%	0.149%
	X_2 : bank_dep	0.002%	0.002%	0.017%	0.001%	0.001%	0.001%	0.001%	0.000%	0.005%
	X_3 : dep_inv	0.000%	0.000%	0.044%	0.155%	0.434%	0.577%	0.328%	0.403%	1.037%
	X_4 : free	2.119%	2.326%	1.683%	1.482%	1.479%	2.454%	2.260%	1.951%	4.875%
	X_5 : inter_rel	6.010%	7.371%	4.892%	7.647%	9.082%	6.359%	7.994%	5.627%	11.601%
	X_6 : cred_op	15.543%	15.152%	8.170%	11.225%	15.288%	16.544%	17.411%	17.069%	17.665%
	X_7 : oth_assets	76.326%	75.149%	85.193%	79.489%	73.714%	74.066%	72.005%	74.949%	64.668%
Liability and equity accounts (%)	Y_1 : dem_dep	1.694%	1.552%	0.962%	1.612%	2.658%	2.985%	5.032%	3.925%	4.325%
	Y_2 : inter_dep	0.065%	0.043%	0.019%	0.053%	0.162%	0.376%	0.332%	0.361%	0.752%
	Y_3 : term_dep	11.312%	12.476%	7.986%	10.879%	13.593%	13.009%	13.395%	11.241%	12.692%
	Y_4 : fund_acc	0.091%	0.121%	0.125%	0.214%	0.332%	0.392%	0.356%	0.610%	1.762%
	Y_5 : inter_on	2.370%	3.106%	1.731%	2.465%	3.264%	3.330%	3.636%	4.145%	5.466%
	Y_6 : inter_rel	0.001%	0.025%	0.012%	0.015%	0.001%	0.001%	0.015%	0.020%	0.113%
	Y_7 : loan_obl	1.440%	0.417%	0.221%	0.159%	0.046%	0.056%	0.082%	0.136%	0.310%
	Y_8 : share_eq	3.863%	4.241%	2.529%	3.598%	4.617%	4.497%	3.768%	3.141%	4.378%
	Y_9 : oth_liab	79.163%	78.020%	86.415%	81.005%	75.327%	75.354%	73.382%	76.423%	70.202%

Note: For the list of variables and their description, see Table 1.**Source:** Prepared by the authors.

Table 3
Pearson correlation coefficients for credit unions (2014-2022)

	cash	bank_dep	dep_inv	free	inter_rel	cred_op	oth_assets	dem_dep	inter_rel	term_dep	fund_acc	inter_on	interdep	loan_obl	share_eq	oth_liab
cash	1.000															
bank_dep	0.061 (0.000)	1.000														
dep_inv	0.060 (0.000)	-0.009 (0.479)	1.000													
free	0.028 (0.039)	-0.002 (0.850)	0.306 (0.000)	1.000												
inter_rel	0.085 (0.000)	-0.027 (0.045)	0.211 (0.000)	0.179 (0.000)	1.000											
cred_op	0.088 (0.000)	-0.048 (0.000)	0.376 (0.000)	0.580 (0.000)	0.711 (0.000)	1.000										
oth_assets	0.048 (0.000)	-0.016 (0.214)	0.402 (0.000)	0.473 (0.000)	0.679 (0.000)	0.877 (0.000)	1.000									
dem_dep	0.135 (0.000)	-0.038 (0.004)	0.379 (0.000)	0.456 (0.000)	0.741 (0.000)	0.868 (0.000)	0.834 (0.000)	1.000								
inter_rel	0.086 (0.000)	-0.041 (0.002)	0.130 (0.000)	0.313 (0.000)	0.213 (0.000)	0.434 (0.000)	0.314 (0.000)	0.383 (0.000)	1.000							
term_dep	0.084 (0.000)	-0.009 (0.468)	0.378 (0.000)	0.580 (0.000)	0.827 (0.000)	0.892 (0.000)	0.815 (0.000)	0.817 (0.000)	0.338 (0.000)	1.000						
fund_acc	0.040 (0.002)	0.011 (0.408)	0.429 (0.000)	0.195 (0.000)	0.230 (0.000)	0.386 (0.000)	0.500 (0.000)	0.400 (0.000)	-0.013 (0.320)	0.316 (0.000)	1.000					
inter_on	0.113 (0.000)	-0.072 (0.000)	0.294 (0.000)	0.430 (0.000)	0.523 (0.000)	0.791 (0.000)	0.627 (0.000)	0.676 (0.000)	0.376 (0.000)	0.591 (0.000)	0.264 (0.000)	1.000				
inter_rel	0.045 (0.000)	0.042 (0.002)	0.040 (0.003)	-0.001 (0.890)	-0.070 (0.000)	-0.028 (0.035)	0.025 (0.065)	-0.001 (0.936)	-0.031 (0.021)	-0.042 (0.002)	0.107 (0.000)	-0.039 (0.003)	1.000			
loan_obl	-0.007 (0.592)	0.002 (0.853)	0.023 (0.084)	0.137 (0.000)	0.110 (0.000)	0.228 (0.000)	0.239 (0.000)	0.155 (0.000)	0.002 (0.848)	0.127 (0.000)	0.154 (0.000)	0.144 (0.000)	0.033 (0.013)	1.000		
share_eq	0.098 (0.000)	-0.041 (0.002)	0.370 (0.000)	0.590 (0.000)	0.726 (0.000)	0.899 (0.000)	0.800 (0.000)	0.797 (0.000)	0.345 (0.000)	0.847 (0.000)	0.347 (0.000)	0.688 (0.000)	-0.029 (0.028)	0.213 (0.000)	1.000	
oth_liab	0.034 (0.010)	-0.014 (0.278)	0.375 (0.000)	0.454 (0.000)	0.677 (0.000)	0.854 (0.000)	0.984 (0.000)	0.782 (0.000)	0.267 (0.000)	0.802 (0.000)	0.464 (0.000)	0.597 (0.000)	0.023 (0.083)	0.257 (0.000)	0.790 (0.000)	1.000

Note: See Table 1 for the list of variables and their descriptions. *P*-value is in parentheses.

Source: Prepared by the authors.

lowest liability balances were found in interdependence relationships, loan obligations and interbank deposits.

Table 3 shows the Pearson correlation coefficients using a 5% significance level.

It can be seen that free resources have an intermediate correlation with term deposits and shareholders' equity. Interbank relationships have an intermediate correlation with interbank onlending and other liabilities, a high correlation with demand deposits and shareholders' equity, and are strongly associated with term deposits. Credit operations have a high correlation with interbank onlending and are strongly associated with demand deposits, term deposits, shareholders' equity and other liabilities. Other assets have a moderate correlation with foreign exchange acceptances and are strongly associated with demand deposits, term deposits, shareholders' equity and other liabilities. Shareholders' equity has an intermediate correlation with free resources, a high correlation with interbank relationships, and is strongly associated with credit operations and other assets. Liabilities generally show significant correlations with almost all asset positions. These results confirm the banking literature (Abou-El-Sood & El-Ansary, 2017).

Possible explanations for credit unions are related to the nature of the business, which consists of financial intermediation by raising and allocating funds without the goal of profit maximization (Bittencourt et al., 2017). Also noteworthy is risk management, which aims to balance maturities and mitigate exposure to interest rate risk (Mommel & Schertler, 2012; Simonson et al., 1983; De Young & Yom, 2008), as well as regulatory standards, such as Basel III, which ensure financial stability.

4.2 Temporal Evolution of the Dependence of Asset and Liability Accounts

The results of the canonical correlation analysis are presented in Table 4. Seven canonical correlations were calculated, the maximum allowed according to the way the asset and liability accounts were grouped. The asset and liability variables show a relatively high degree of collective dependence.

In 2014, the first canonical correlation was 0.99, meaning that the first factor extracted from the asset account data and the first factor extracted from the liability account data have a linear correlation of 0.99. The second canonical correlation was 0.94. Going down each column, it can be seen that the canonical correlations decrease in explanatory power and statistical significance.

In the first column, the first F-statistic value of 213.93 (p-value 0.000) rejects the null hypothesis that all seven canonical correlations are null. The second F-statistic value of 63.31 (p-value 0.000) rejects the hypothesis for the second to seventh correlations. The canonical pairs from the third to the fifth have significant values, while the pairs from the sixth and seventh are not significant (except for the sixth canonical pair of 2019). It can be concluded that, in general, five or fewer canonical pairs are sufficient to represent ALM.

Table 4 shows the canonical correlations between linear combinations of asset and liability variables, which may or may not reflect systematic relationships between these variables. To assess these relationships, we have the redundancy coefficient in Table 5, which measures the variance shared between the independent and dependent variables, providing a summary index of the average strength and ability of a predictor variable to explain the variability in a set of dependent variables (Abou-El-Sood & El-Ansary, 2017).

The canonical liability variables explain about 5.02% of the variation in the asset variables, while the canonical asset variables explain about 5.23% of the variation in the liability variables. These results indicate, first, that causality tends to be stronger from assets to liabilities, suggesting that credit unions seek financing and define such strategies after identifying investment opportunities, similar to the findings of DeYoung and Yom (2008). Second, the small size of the redundancy coefficients and the significance of the first two loadings suggest that the strong canonical correlations in Table 4 result from a relatively small number of specific relationships between discretionary asset and liability accounts.

Figure 1 shows a discrete increase, with possible convergence, in the level of linkage of discretionary accounts, suggesting that credit unions may have become more similar over time. The results are consistent with the first hypothesis (H1) that there is a positive trend over time in the dependence of discretionary asset and liability accounts in credit unions, reflecting improvements in management practices and adaptation to regulatory requirements.

The results differ from those of DeYoung and Yom (2008), who found a reduction in asset-liability linkages in US commercial banks between 1990 and 2005, and Mommel and Schertler (2012), who found a reduction in all sectors of German banks between 1994 and 2007. With the growth of credit unions in Brazil (BCB, 2022), ALM has become essential, as the expansion of activities and

Table 4
Temporal evolution of ALM in credit unions (2014-2022)

Canonical function	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)
1	0.997	213.931 (0.000)	0.999	257.396 (0.000)	0.999	296.187 (0.000)	0.999	375.505 (0.000)	0.999	281.733 (0.000)	0.999	257.381 (0.000)	0.999	235.616 (0.000)	0.996	142.114 (0.000)	1.000	2361.264 (0.000)
2	0.944	63.314 (0.000)	0.950	54.143 (0.000)	0.953	80.135 (0.000)	0.959	93.203 (0.000)	0.947	58.828 (0.000)	0.948	50.482 (0.000)	0.952	50.399 (0.000)	0.938	41.971 (0.000)	0.998	181.288 (0.000)
3	0.724	22.707 (0.000)	0.579	12.860 (0.000)	0.836	35.115 (0.000)	0.873	43.250 (0.000)	0.633	20.672 (0.000)	0.653	14.450 (0.00)	0.641	13.661 (0.000)	0.628	11.296 (0.000)	0.704	22.497 (0.000)
4	0.451	9.444 (0.000)	0.438	6.870 (0.000)	0.448	11.789 (0.000)	0.580	13.828 (0.000)	0.574	15.068 (0.000)	0.350	6.375 (0.000)	0.381	6.370 (0.000)	0.302	4.187 (0.000)	0.613	14.437 (0.000)
5	0.299	4.641 (0.000)	0.174	1.691 (0.046)	0.409	8.811 (0.000)	0.260	3.831 (0.000)	0.371	6.708 (0.000)	0.305	5.065 (0.000)	0.287	4.192 (0.000)	0.255	3.182 (0.000)	0.324	4.937 (0.000)
6	0.093	0.906 (0.510)	0.094	0.731 (0.664)	0.132	1.742 (0.084)	0.132	1.683 (0.097)	0.128	1.286 (0.246)	0.175	2.429 (0.013)	0.139	1.847 (0.064)	0.125	1.375 (0.203)	0.153	1.817 (0.070)
7	0.048	0.516 (0.670)	0.016	0.060 (0.980)	0.069	1.003 (0.390)	0.064	0.853 (0.465)	0.024	0.113 (0.952)	0.055	0.579 (0.628)	0.085	1.327 (0.264)	0.068	0.833 (0.475)	0.061	0.667 (0.572)
Observations	660	660	641	641	629	629	626	626	602	602	573	573	555	555	544	544	531	531

Note: CC corresponds to canonical correlation and F Stat. corresponds to F-statistic.

Source: Prepared by the authors.

Table 5
Redundancy coefficient (2014-2022)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Variance of the asset variables explained by the canonical liability variables	0.513	0.475	0.564	0.591	0.532	0.518	0.549	0.558	0.723	5.027
Variance of the liability variables explained by the canonical asset variables	0.538	0.527	0.576	0.585	0.557	0.575	0.571	0.599	0.704	5.235

Source: Prepared by the authors.

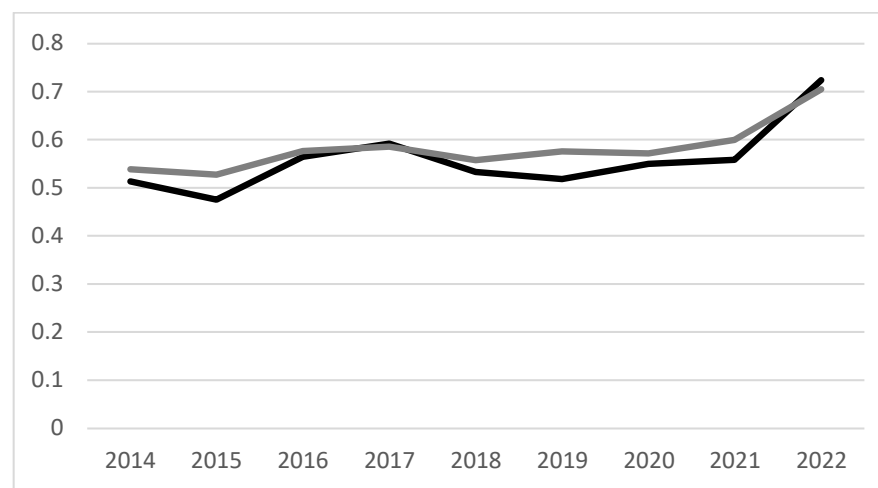


Figure 1 Variation in assets (liabilities) explained by liabilities (assets) (2014-2022)

Note: Black line corresponds to variation in assets explained by liabilities. Grey line corresponds to variation in liabilities explained by assets.

Source: Prepared by the authors.

diversification of services have increased the complexity of risk management. The consolidation of the sector and the evolution of risk instruments intensify the need for a more precise approach to ALM, which is fundamental to ensuring the financial stability and efficiency of credit unions.

4.3 Findings on the Size of the Dependences between Asset and Liability Accounts

The canonical correlations were analyzed by credit union size, with the sample divided into quartiles, from the first quartile (smallest size) to the fourth quartile (largest size), as shown in Table 6.

The Wilks' Lambda test statistic rejected hypothesis H_0 : two vectors of variables are not linearly related. The Wilks' Lambda test value was low, indicating that the dependent and independent variables are significantly related. The p-value was lower than the significance level (5%), so there is a significant relationship between the dependent and independent variables. The Pillai's Trace and Lawley-Hotelling Trace tests produce results similar to statistical significance, which is common (Fávero &

Belfiore, 2024). In addition, the inferences are based on asymptotic assumptions.

The canonical R^2 of the first pair of variables for smaller credit unions (a) was 99.80%, higher than the canonical R^2 for larger credit unions (b), which was 98.20%. The results suggest that for smaller credit unions, discretionary accounts are better explained by canonical models, are more closely related to each other, and are more predictable. For smaller credit unions, the proportion of variation in the asset variables that was predictable from the liability variables was 0.629. The proportion of variation in the liability variables that was predictable from the asset variables was 0.641, according to the redundancy index calculation. For larger credit unions, the redundancy indices are relatively lower (0.500 and 0.521). These results may reflect a more diversified financial structure in larger credit unions, making it difficult to explain the variations between discretionary asset and liability accounts.

In practice, smaller credit unions may have a simpler and more cohesive financial structure, which can make ALM more effective. It also optimizes the allocation of capital and resources (Dermine, 2012) due to the more predictable relationships between discretionary

Table 6
Canonical correlations by size (2014-2022)

Canonical function	(a) Smaller credit unions (1st quartile)			(b) Larger credit unions (4th quartile)		
	Canonical correlation	Canonical R^2	F-statistic (p-value)	Canonical correlation	Canonical R^2	F-statistic (p-value)
1	0.999	0.998	983.813 (0.000)	0.991	0.982	279.280 (0.000)
2	0.987	0.974	242.064 (0.000)	0.939	0.881	103.337 (0.000)
3	0.658	0.432	59.599 (0.000)	0.550	0.302	25.954 (0.000)
4	0.624	0.389	47.394 (0.000)	0.375	0.140	15.745 (0.000)
5	0.459	0.210	25.203 (0.000)	0.298	0.088	11.043 (0.000)
6	0.173	0.029	5.660 (0.000)	0.158	0.024	4.798 (0.000)
7	0.055	0.003	1.370 (0.250)	0.058	0.003	1.511 (0.209)
Observations	1,341	1,341	1,341	1,340	1,340	1,340
Statistical tests	Value	F Stat. (p-value)		Value	F Stat. (p-value)	
Wilks' Lambda	0.000	983.813 (0.000)		0.001	279.280 (0.000)	
Pillai's Trace	3.043	113.757 (0.000)		2.426	78.415 (0.000)	
Lawley-Hotelling Trace	1,900.100	39,910.623 (0.000)		64.072	1,344.784 (0.000)	

Source: Prepared by the authors.

accounts. For larger credit unions, the less predictable relationship between accounts may suggest the need for more diversified management strategies and more advanced risk control methods. Thus, the results are more consistent with the second hypothesis (H2) that the discretionary asset and liability accounts dependence is greater in small credit unions.

The results found for Brazilian credit unions are higher than those for Islamic banks, as shown by Abou-El-Sood and El-Ansary (2017). For smaller credit unions, the redundancy index was 0.629, compared to 0.450 for Islamic banks. Larger credit unions, on the other hand, have an index of 0.500, which is higher than the 0.420 for Islamic banks. In addition, these results for larger credit unions exceed those found for American commercial banks, where Simonson et al. (1983) reported redundancy indices of 0.320 and 0.370 for large banks (assets under US\$ 1 billion) and 0.460 and 0.390 for very large banks (assets over US\$ 1 billion), while larger credit unions had indices of 0.500 and 0.521. For non-financial companies, the redundancy index was even lower (Stowe et al., 1980).

4.4 Results for Periods of Economic Crises and their Absence

Table 7

Canonical correlations (periods of economic crises and their absence)

Canonical function	(a) Periods with economic crises			(b) Periods without economic crises		
	Canonical correlation	Canonical R ²	F-statistic (p-value)	Canonical correlation	Canonical R ²	F-statistic (p-value)
1	0.996	0.993	454.175 (0.000)	0.995	0.990	804.527 (0.000)
2	0.925	0.856	120.010 (0.000)	0.926	0.859	243.665 (0.000)
3	0.486	0.237	28.078 (0.000)	0.555	0.308	62.351 (0.000)
4	0.412	0.169	18.736 (0.000)	0.331	0.109	31.699 (0.000)
5	0.210	0.044	6.555 (0.000)	0.264	0.070	22.242 (0.000)
6	0.085	0.007	1.881 (0.058)	0.123	0.015	9.072 (0.000)
7	0.030	0.000	0.547 (0.649)	0.071	0.005	5.955 (0.000)
Observations	1,825	1,825	1,825	3,536	3,536	3,536
Statistical tests	Value	F Stat. (p-value)		Value	F Stat. (p-value)	
Wilks' Lambda	0.000	454.175 (0.000)		0.000	804.527 (0.000)	
Pillai's Trace	2.309	99.325 (0.000)		2.357	198.961 (0.000)	
Lawley-Hotelling Trace	165.542	4,748.911 (0.000)		105.944	5,916.547 (0.000)	

Note: Periods with economic crises (2015, 2016 and 2020) and periods without economic crises (2014, 2017, 2018, 2019, 2021 and 2022).

Source: Prepared by the authors.

The canonical correlations were analyzed for periods with economic crises and without economic crises, as shown in Table 7. The canonical R² of the first pair of variables in periods with crises (a) was 99.38%, higher than the canonical R² of 99.00% for periods without crises (b).

The results may indicate that in periods with crises, credit union managers may manage discretionary accounts more optimally to maintain financial equilibrium, possibly reflecting a greater ability to respond to change. In addition, the relationship between these accounts may become more predictable and clearer.

In practice, credit unions may show greater resilience in periods of economic crisis, reflecting a better allocation of discretionary accounts, which may contribute to financial stability and the adoption of efficient ALM strategies (Tektaş et al., 2005). Abou-El-Sood and El-Ansary (2017) also observed differences in ALM during crises.

The results are consistent with the third hypothesis (H3) that discretionary asset and liability account dependence is greater during periods of economic crisis in credit unions.

4.5 Other Robustness Checks

Table 8
Temporal evolution of ALM in credit unions (2014-2022)

Canonical function	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)	CC	F-stat (p-value)
1	0.988	443.741 (0.000)	0.993	507.646 (0.000)	0.991	434.173 (0.000)	0.986	371.334 (0.000)	0.989	376.822 (0.000)	0.996	525.737 (0.000)	0.996	533.446 (0.000)	0.996	507.739 (0.000)	0.996	480.440 (0.000)
2	0.644	60.353 (0.000)	0.376	27.959 (0.000)	0.381	24.245 (0.000)	0.422	27.059 (0.000)	0.381	17.598 (0.000)	0.363	11.605 (0.000)	0.328	9.567 (0.000)	0.455	18.975 (0.000)	0.315	9.222 (0.000)
3	0.326	21.726 (0.000)	0.330	32.186 (0.000)	0.296	23.339 (0.000)	0.307	21.188 (0.000)	0.236	10.400 (0.000)	0.102	1.959 (0.098)	0.130	2.752 (0.026)	0.149	4.604 (0.001)	0.170	4.480 (0.001)
4	0.058	2.517 (0.113)	0.225	39.346 (0.000)	0.174	23.253 (0.000)	0.106	8.492 (0.003)	0.029	0.603 (0.437)	0.037	0.908 (0.340)	0.007	0.034 (0.853)	0.084	4.436 (0.035)	0.004	0.012 (0.911)
Observations	734	734	742	742	743	743	749	749	708	708	665	665	645	645	624	624	607	607

Note: Asset accounts (X_1 cash and cash equivalents; X_2 short-term investments; X_3 long-term investments; X_4 permanent), liability accounts (Y_1 deposits; Y_2 short-term obligations; Y_3 long-term obligations; Y_4 shareholders' equity), adapted from Bittencourt and Bressan (2016), for 750 credit unions, from 2014 to 2022, totaling 6,217 observations. CC corresponds to canonical correlation and F Stat. corresponds to F-statistic.

Source: Prepared by the authors.

To deepen the robustness analysis, canonical correlations with accounts that provide a macroeconomic perspective on ALM were performed, following Bittencourt and Bressan (2016). Table 8 shows the temporal evolution of the dependence of macroeconomic accounts.

Four canonical correlations were calculated, and the macroeconomic variables show a high degree of collective dependence, similar to that obtained in the discretionary accounts. In 2014, the first canonical correlation was 0.98, while the second was 0.64. There was a decrease in the correlations in terms of explanatory power and statistical significance, going down in each column. As for the value of the F-statistic, three or fewer canonical pairs are sufficient to represent ALM.

There is also a discrete but not monotonic increase in the dependence of these accounts. In general, the variation in assets explained by liabilities shows a slight increase over the years. The variation in liabilities explained by assets, although lower, also tends to recover in some years, with higher values in 2021 and 2022. According to Figure 2, this may indicate that, even with some fluctuations, there

is a certain stability over time, which may reflect a positive evolution of dependence, reflecting better management practices and regulatory adaptation.

When analyzing the canonical correlations according to size, taking into account the macroeconomic variables, the canonical R^2 of the first pair of variables for smaller credit unions (a) was 99.80, higher than the R^2 of 97.02% for larger credit unions (b). The results obtained with the discretionary accounts are similar, suggesting that the use of macroeconomic accounts does not alter the results with respect to the size of the credit unions.

Also, for the canonical correlations in periods of economic crises and their absence, the R^2 of the first pair of variables during crises (a) was 98.78%, higher than the canonical R^2 of the first pair of variables in periods without crises (b), which was 98.52%. These results are similar to those observed in the discretionary accounts. This suggests that the results remain consistent in both crisis and non-crisis periods, regardless of the macroeconomic accounts approach.

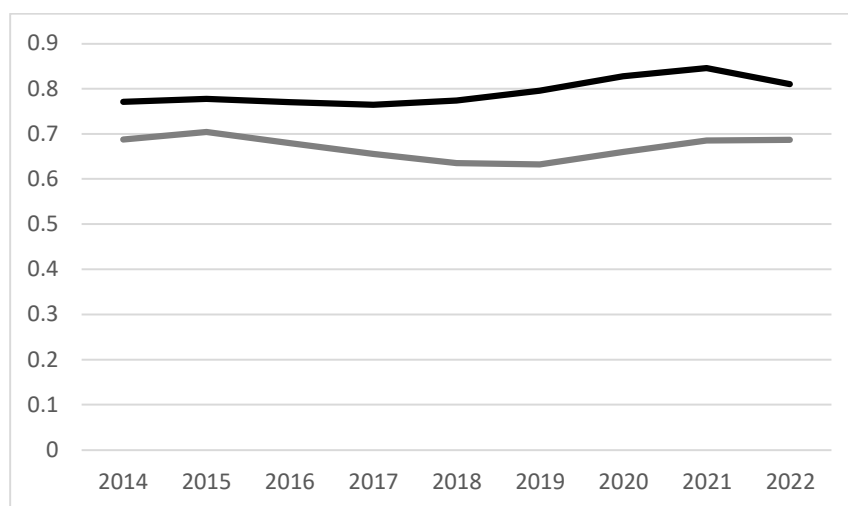


Figure 2 Variation in assets (liabilities) explained by liabilities (assets) (2014-2022)

Note: Black line corresponds to variation in assets explained by liabilities. Grey line corresponds to variation in liabilities explained by assets.

Source: Prepared by the authors.

The analyses using macroeconomic and discretionary accounts showed homogeneous results and may indicate consistency in the ALM relationships in the credit unions. This suggests that ALM can be effective in promoting

stability in resource management and minimizing risks. In addition, the adaptability of the credit unions to different economic contexts may highlight their resilience (Tektaş et al., 2005) and efficiency in financial management.

5 CONCLUSION

The study aimed to analyze the matching of discretionary asset and liability accounts in Brazilian credit unions, and its evolution over time. For this purpose, data were collected from 672 credit unions from 2014 to 2022, totaling 5,361 observations.

The results show that ALM can be applied to an average of twenty percent of discretionary accounts, with a positive evolution in the dependence of these accounts in credit unions over time, consistent with the first hypothesis (H1). The expansion of activities and the diversification of services may require a greater application of ALM due to the complexity of risk management, in contrast to the international context (DeYoung & Yom, 2008; Memmel & Schertler, 2012), which shows a reduction in dependence.

In terms of size, it is suggested that discretionary asset and liability account dependence may be greater for smaller credit unions, which is consistent with the second hypothesis (H2). In practice, smaller credit unions may have a simpler financial structure, which may facilitate more efficient management, allowing for a more optimized allocation of capital and resources (Dermine, 2012), due

to greater predictability in the relationships between discretionary accounts.

Considering periods of economic crises and their absence, it was found that managers may have adopted more efficient ALM strategies during crises, a result consistent with the third hypothesis (H3). In practice, credit unions may show greater resilience during crises by optimizing the allocation of accounts and adopting more effective ALM strategies to maintain financial stability (Tektaş et al., 2005).

As a limitation of the study, it was not possible to consider the maturity of the accounts, as suggested by DeYoung and Yom (2008) and Memmel and Schertler (2012), because the discretionary accounts classified as short- and long-term assets and liabilities were not available on the BACEN website. In addition to not considering the maturity of assets and liabilities, the risk associated with interest rates was also not considered.

Future studies could examine the ALM of credit unions at a global level. They could also examine the maturity of assets and liabilities and the use of interest rate hedging mechanisms by financial institutions.

REFERENCES

- Abou-El-Sood, H., & El-Ansary, O. (2017). Asset-liability management in Islamic banks: evidence from emerging markets. *Pacific Accounting Review*, 29(1), 55-78. <https://doi.org/10.1108/PAR-04-2016-0050>
- Alves, M. F. H., & Moreira, J. C. (1996). Risco de taxas de juros: inovações na gestão de ativos e passivos de instituições financeiras. *Revista de Administração de Empresas*, 36(3), 54-60. <https://doi.org/10.1590/S0034-75901996000300007>
- Bartlett, M. S. (1947). Multivariate analysis. Supplement to the journal of the royal statistical society, 9(2), 176-197.
- Banco Central do Brasil (BCB) (2022). *Panorama do sistema nacional de crédito cooperativo*. Retrieved from https://www.bcb.gov.br/content/estabilidade/financeira/coopcredpanorama/Panorama_do_sistema_nacional_de_credito_cooperativo_v3.pdf
- Bittencourt, W. R. et al. (2017). Profitability in multiple Brazilian banks and credit unions. *Journal of Contemporary Administration*, 21, special edition, 22-40. <http://dx.doi.org/10.1590/1982-7849rac2017150349>
- Bittencourt, W. R., & Bressan, V. F. G. (2016). The capital structure of credit unions affiliated to Sicredi. *Revista de Gestão e Contabilidade da UFPI*, 3(2), 37-51. <https://doi.org/10.26694/2358.1735.2016.v3ed24421>
- Bressan, V. G. F., Souza, D. C., & Bressan, A. A. (2017). Income smoothing: a study of the health sector's credit unions. *Review of Business Management*, 19(66), 627-643. <https://doi.org/10.7819/rbgn.v0i0.2617>
- Carvalho, F. L., Diaz, M. D. M., Bialoskorski, S. N., & Kalatzis, A., E. G. (2015). Exit and failure of credit unions in Brazil: a risk analysis. *Accounting & Finance Review*, 26(67), 70-8. <https://doi.org/10.1590/1808-057x201411390>
- Dermine, J. (2012). *Gerenciamento de ativos e passivos - um guia para a criação de valor e controle de riscos*. 2. ed. São Paulo: Atlas.
- DeYoung, R., & Yom, C. (2008). On the independence of assets and liabilities: evidence from U.S. commercial banks, 1990-2005. *Journal of Financial Stability*, 4(1), 275-303. <https://doi.org/10.1016/j.jfs.2008.04.001>

- Fantin, L., & Kondo, D. Y. S. (2015). *Gestão de ativos e passivos: uma perspectiva pragmática para ALM em bancos*. Editora: Dash.
- Fávero, L. P., & Belfiore, P. (2024). *Manual de análise de dados: estatística e machine learning com Excel®, SPSS®, Stata®, R® e Python®*. Editora: Gen Ltd.
- Filip, A., & Raffournier, B. (2014). Financial crisis and earnings management: the European evidence. *The International Journal of Accounting*, 49(4), 455-478. <https://doi.org/10.1016/j.intacc.2014.10.004>
- Francis, J. C. (1978). Portfolio analysis of asset and liability management in small-, medium- and large-sized banks. *Journal of Monetary Economics*, 4, 459-480. [https://doi.org/10.1016/0304-3932\(78\)90042-9](https://doi.org/10.1016/0304-3932(78)90042-9)
- Fraser, D. R., Phillips, W., & Rose, P. S. (1974). A canonical analysis of bank performance. *Journal of Financial and Quantitative Analysis*, 9(2), 287-295. <https://doi.org/10.2307/2330107>
- Gollo, V., & Silva, T. P. (2015). Global efficiency in the economic and financial performance of Brazilian credit unions. *Journal of Accounting and Organizations*, 9(25), 43-55. <http://dx.doi.org/10.11606/rco.v9i25.88099>
- Iatridis, G., & Dimitras, A. I. (2013). Financial crisis and accounting quality: evidence from five European countries. *Advances in Accounting*, 29, 154-160. <http://dx.doi.org/10.1016/j.adiaac.2013.03.001>
- Leão, L. L., Martins, P. S., & Locatelli, R. L. (2012). Risks and asset and liability management: a case study of Banco de Desenvolvimento de Minas Gerais S/A. *Journal of Management & Technology*, 12(3), 3-25.
- Lysiak, L. et al. (2022). Banking risks in the asset and liability management system. *Journal of Risk and Financial Management*, 15(6), 265. <https://doi.org/10.3390/jrfm15060265>
- McKillop, D., et al. (2020). Cooperative financial institutions: A review of the literature. *International Review of Financial Analysis*, 71, 101520. <https://doi.org/10.1016/j.irfa.2020.101520>
- Memmel, C., & Schertler, A. (2012). The dependency of the banks' assets and liabilities: evidence from Germany. *European Financial Management*, 18(4), 602-619. <https://doi.org/10.1111/j.1468-036X.2010.00543.x>
- Owusu, F. B., & Alhassan, A. L. (2021). Asset-liability management and bank profitability: statistical cost accounting analysis from an emerging market. *International Journal of Finance and Economics*, 26(1), 1488-1502. <https://doi.org/10.1002/ijfe.1860>
- Simonson, D. G., Stowe, D. J., & Watson, C. J. (1983). A canonical correlation analysis of commercial bank asset/liability structures. *Journal of Financial and Quantitative Analysis*, 18, 125-140. <https://doi.org/10.2307/2330808>
- Stowe, J. D., Watson, C. J., & Robertson, T. D. (1980). Relationships between the two sides of the balance sheet: a canonical correlation analysis. *Journal of Finance*, 35(4), 973-980. <https://www.jstor.org/stable/2327214>
- Stowe, D. L., & Stowe, J. D. (2018). Credit union business models. *Financial Markets, Institutions & Instruments*, 27(1), 169-186. <https://doi.org/10.1111/fmii.12102>
- Tektas, A., Ozkan-Gunay, E. N., & Gunay, G. (2005). Asset and liability management in financial crisis. *The Journal of Risk Finance*, 6(2), 135-149. <http://dx.doi.org/10.1108/15265940510585806>

FUNDING

The authors are grateful to the Brazilian Coordination for the Improvement of Higher Education Personnel [Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (Capes)] – Finance Code 001.