

Financial Competitiveness and Resilience Under Tension: A Comparative Analysis Between Banks and Savings and Credit Cooperatives in Colombia (2016–2024) Through Benchmarking and Clustering

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ABSTRACT

Introduction. The literature on financial competitiveness and resilience has favored individual studies of banks or cooperatives, leaving a gap in comparative analysis of both sectors within a common methodological framework. This research addressed this gap by directly comparing the three leading banks and three leading savings and credit cooperatives in Colombia, selected for their asset and income levels, over the period 2016–2024.

Objectives. The central purpose was to analyze how competitiveness and resilience manifested in entities with different capital structures and scales of operation, establishing points of convergence and divergence in their financial dynamics.

Method. A quantitative, longitudinal, and comparative approach was applied using benchmarking and cluster analysis. Time series were constructed with key indicators of solvency, leverage, indebtedness, autonomy, profitability (ROA and ROE), and economic margin, calculated from official reports of supervisory and regulatory entities. The analysis included descriptive statistics, centroid validation, and ANOVA tests, enabling characterization of persistent patterns and periods of critical volatility.

Results: Banks concentrated economies of scale, although with high exposure to leverage risks and low levels of autonomy. Cooperatives, in contrast, showed greater capital strength and relative efficiency in asset use, standing out in resilience to financial shocks. The comparative benchmark of the six leading institutions revealed that competitiveness depended not only on size but also on the capacity to maintain balanced capital structures.

Discussion: These findings broadened understanding of the Colombian financial system as a hybrid ecosystem in which banks and cooperatives play complementary roles in intermediation. The evidence showed that resilience is not the exclusive domain of large institutions, but can be strengthened through robust capital strategies and prudent risk management.

Conclusions: The study provided original evidence on the direct comparison between banks and cooperatives through benchmarking and clustering, demonstrating that the tension between competitiveness and resilience depends on structural factors rather than size. As a practical contribution, the results offer inputs for financial regulation aimed at balancing competition and stability, as well as for the strategic management of entities seeking to strengthen their performance in volatile environments.

Keywords: financial competitiveness; resilience; benchmarking; clustering; banks; savings and credit cooperatives; Colombia.

INTRODUCTION

The literature on financial competitiveness and resilience has historically addressed banks and cooperatives separately, limiting a comprehensive understanding of their dynamics within a common analytical framework. Contributions by Modigliani & Miller (1958) allowed for the conceptualization of capital structure as a key determinant of profitability and risk, although its applicability has been nuanced in contexts of market imperfections and agency costs (Figueira et al., 2009). (Dwekat et al., 2025) In turn, agency theory has highlighted the importance of control mechanisms and corporate governance in reducing conflicts of interest and strengthening institutional stability. However, these perspectives have tended to prioritize internal factors and underestimate external pressures, such as regulatory or macroeconomic ones, which decisively condition competitiveness and resilience in emerging markets.

This study aimed to fill this gap through a comparative analysis of three leading banks and three leading savings and credit cooperatives in Colombia during the period 2016–2024, selected based on their asset and income levels. The combination of a quantitative approach with benchmarking and cluster analysis techniques enabled the identification of structural similarities and differences in scale, profitability, and capital strength. The application of these methodologies provided a dynamic and objective perspective on the financial trajectories of entities that, while sharing the same regulatory and macroeconomic environment, operate with distinct organizational models.

The Colombian context is particularly relevant, as the financial system combines large-scale banking institutions with cooperatives that, although smaller, fulfill critical functions for inclusion and regional stability. This hybrid nature demands diagnostic tools that go beyond the isolated comparison of indicators and enable a comprehensive assessment of how competitiveness and resilience are articulated within institutions with different characteristics. By adopting clustering as a segmentation technique and validating the centroids using ANOVA, the study provided a robust framework for identifying consistent financial patterns and detecting performance gaps.

In practical terms, this work addressed the need for more precise comparative frameworks for emerging markets, where the coexistence of banks and cooperatives poses challenges for regulation and strategic management. The findings helped to outline distinct improvement scenarios: for banks, the focus was on maintaining profitability and managing leverage, while for cooperatives, the challenge was to capitalize on their capital strength to sustain efficiency in volatile environments. Thus, the study reinforced the usefulness of benchmarking and clustering as diagnostic tools applicable to financial systems with heterogeneous structures.

State of the art

The state of the art regarding financial competitiveness and resilience in the banking and cooperative sector was constructed using a search equation designed to capture the main lines of international research. The strategy included terms associated with financial performance and efficiency (“financial competitiveness,” “financial performance,” “financial resilience,” “bank efficiency,” “profitability analysis”), as well as predominant analytical methodologies in the literature (“benchmarking,” “cluster analysis,” “DEA,” “panel data,” “time series analysis,” “comparative analysis”). Similarly, the different types of institutions under study (“banks,” “commercial banks,” “credit unions,” “cooperative banks,” “savings and credit cooperatives”) and the geographical area of interest (“Colombia,” “Latin America,” “emerging markets”) were incorporated. This systematic review allowed for the identification not only of the methodological and thematic trends that have dominated the analysis of financial performance in emerging markets, but also of the conceptual and empirical gaps that persist, particularly the limited comparison between banks and savings and credit cooperatives. This lays the groundwork for a critical discussion of how the literature has addressed the tension between competitiveness and resilience, and which contributions are relevant to understanding the dynamics of the Colombian financial system during 2016–2024.

Within the framework of capital structures and agency theory, the analysis of financial competitiveness and resilience has drawn on agency theory and Modigliani and Miller's capital structure theory. Agency theory argued that control mechanisms reduce conflicts of interest, fostering profitability and institutional stability

(Dwekat et al., 2025). (Figueira et al., 2009) However, its emphasis on internal factors underestimated external pressures such as regulation and macroeconomic shocks. In parallel, stakeholder and legitimacy theories posit that social responsibility and accountability strengthen trust and financial soundness by linking social performance to resilience (A.M. et al., 2024). (Alketbi et al., 2022) Nevertheless, these perspectives tended to prioritize reputation over tangible financial effects, limiting their explanatory power. In response, integrating responsible governance and fiscal practices has been proposed to bridge the gap between competitiveness and resilience (A.M. et al., 2024).

Regarding competitiveness, efficiency, and fragility, the industrial theory of organization and the structure-behavior-performance paradigm linked liberalization with financial efficiency, supporting the efficient structure hypothesis (Hermes & Nhung, 2010). (Alhassan & Ohene-Asare, 2016) However, the fragility hypothesis warned that excessive competition erodes margins and fosters systemic risks, creating an unresolved dilemma in emerging markets (Hermes & Nhung, 2010). (Alhassan & Ohene-Asare, 2016) This tension led to recommendations for adaptive regulatory frameworks. Other approaches, such as the resource-based view and intellectual capital, emphasize that knowledge, human capital, and reputation are sources of competitive advantage that positively affect ROA and ROE (Onumah & Duho, 2020). (Abebe Zelalem & Ali Abebe, 2022) Although (Buenaño et al., 2025) useful, these perspectives focused on internal capabilities showed limitations by not considering portfolio quality or revenue diversification, factors that can turn competitiveness into vulnerability (Alhassan, 2015). (Gardener et al., 2011) Following the global crisis, mergers and acquisitions emerged as a strengthening response, with effects conditioned by the context (K. Du & Sim, 2016). At scale, the benefits of size coexisted with systemic risks (Ofori et al., 2025). (Jalloul & Haque, 2025) In the Colombian case, where banks and cooperatives coexist under unequal competitive pressures, this dilemma is particularly relevant.

Governance, digitalization, sustainability, and environmental, social, and governance (ESG) practices have emerged as key drivers of competitive resilience by strengthening operational efficiency, financial inclusion, institutional stability, and adaptive capacity, particularly in emerging-market contexts (M. Du & Li, 2024; Al Azizah & Haron, 2025; Almustafa, 2025). Recent studies further suggest that the strategic integration of governance and innovation can overcome the limitations of fragmented or isolated management frameworks; however, the magnitude of these benefits depends on each institution's technological capabilities, governance quality, and level of organizational maturity (Mirza et al., 2025; Alketbi et al., 2022). Digital transformation also produces a dual effect: while it improves process efficiency, service accessibility, and decision-making capacity, it simultaneously increases exposure to cyber risk and new operational vulnerabilities (Kayed et al., 2025; Ristanović et al., 2025). Institutional size adds another layer of complexity. Large banks can exploit economies of scale, diversification, and technological investment capacity (Gardener et al., 2011; Ofori et al., 2025), but their size and interconnectedness may also concentrate systemic risks and weaken their capacity to respond flexibly to financial shocks (Jalloul & Haque, 2025).

Cooperatives, by contrast, tend to benefit from stronger capitalization, member proximity, and community-based relationships, although they frequently face constraints in achieving sustained profitability and expanding their operational scale (Pîslaru et al., 2023). Overall, the literature indicates that competitiveness and resilience are not opposing outcomes; rather, their relationship is shaped by the quality of governance, income and risk diversification, digital capabilities, institutional scale, and the broader regulatory and socioeconomic environment (Cangombe et al., 2025). This interpretation is consistent with the article's comparative framework, which examines how banks and savings and credit cooperatives combine different levels of scale, capitalization, profitability, and shock-absorption capacity.

Regarding methodologies and technical advances, quantitative approaches predominated: panel models, GMM, and Prais-Winsten for endogeneity and autocorrelation (Cangombe et al., 2025). However, their reliance on linearity assumptions limited their ability to capture institutional and cultural effects. In parallel, efficiency techniques evolved from classical DEA (Staub et al., 2010) to (Sufian & Majid, 2007) sophisticated variants such as Bayesian DEA (Charles et al., 2018) or DEA with unwanted outputs (Pham, 2025), complemented by the stochastic frontier to improve robustness (Hermes & Nhung, 2010). (Alhassan, 2015) Progress was also made in clustering, allowing for the classification of entities according to performance and highlighting gaps (Al Kharusi et al., 2022), (Ofori-Sasu et al., 2019) along with innovations such as ISO 31000 applied to institutional resilience

(Purwanti et al., 2025). Furthermore, progress was made in conditional DEA and common weights to address contextual heterogeneity (Jiménez-Hernández et al., 2019). (Karsak & Goker, 2019) Even so, limitations remain: DEA is sensitive to data quality, SFA does not integrate social outputs, and clustering has been applied without systematic comparisons between banks and cooperatives.

In this critical synthesis, and considering the existing central gap, the state of the art revealed that international literature has advanced in linking efficiency, sustainability, and resilience through diverse theoretical and methodological frameworks (Isik & Uygur, 2021). (Alsadan et al., 2025) However, the findings remained contradictory, partly due to the heterogeneity of contexts and the scarcity of studies that directly compared banks and cooperatives in hybrid markets. In Colombia, the coexistence of both sectors under a shared regulatory environment underscores the need for more precise comparative frameworks. The lack of research integrating benchmarking and clustering in a comparative analysis of banks and cooperatives constitutes the main gap that this research sought to address, thus offering a theoretical and practical contribution to understanding the relationship between competitiveness and resilience in emerging markets.

METHODOLOGY

The study adopted a quantitative, longitudinal, and comparative multiple-case approach to analyze the financial evolution of banks and savings and credit cooperatives in Colombia during the period 2016–2024. Information was obtained from official reports submitted to the Financial Superintendency of Colombia and the Superintendency of the Solidarity Economy, which provided 9 annual observations per entity. Accordingly, the dataset comprised 27 institution-year observations for the banking group and 27 institution-year observations for the cooperative group, for a total of 54 observations. The unit of analysis was each annual record, on which seven financial ratios were calculated: solvency, leverage, indebtedness, autonomy, profit margin, ROA, and ROE. The cluster analysis additionally incorporated four financial magnitudes: assets, liabilities, equity, and net income.

Case selection and scope. The entities were selected through purposive criterion sampling rather than probabilistic sampling. The study included Bancolombia, Banco de Bogotá, and Davivienda as leading banking institutions, and Coomultasan, Fincomercio, and Crediservir as leading savings and credit cooperatives. Selection was based on four criteria: (i) relative importance in terms of assets and operating income within the corresponding sector; (ii) continuity and comparability of financial information for the entire 2016–2024 period; (iii) availability of official reports from the Financial Superintendency of Colombia or the Superintendency of the Solidarity Economy; and (iv) institutional relevance for comparing organizations with different ownership, capitalization, and intermediation structures. Therefore, the study constitutes a comparative analysis of leading cases, not a census or a statistically representative sample of the Colombian financial system. Its conclusions are analytically transferable to institutions with similar profiles but should not be generalized to all banks and cooperatives without additional empirical validation.

The data were organized into time-based panels, cleaned, and consolidated in Excel spreadsheets to ensure consistent units and formats while preserving the traceability of each variable. Once the database was standardized, the defined indicators were calculated: solvency (Assets/Equity), leverage (Assets/Liabilities), debt (Liabilities/Assets), equity (Equity/Assets), profit margin (Operating Income/Total Revenue), ROA (Net Income/Assets), and ROE (Net Income/Equity). Manual implementation of the calculations in worksheets allowed for verification of each operation and ensured methodological transparency.

The statistical analysis included descriptive statistics to characterize the series over the 2016–2024 period. Measures of central tendency (mean, median), dispersion (standard deviation, range), and distribution shape (skewness, kurtosis) were calculated. This analysis, complemented by the clustering performed, facilitated the identification of critical episodes of instability and their relationship to each entity's competitiveness and financial resilience.

Benchmarking procedure. Financial benchmarking was conducted through a sequential comparison at three complementary levels. First, temporal benchmarking examined the annual evolution of each institution between 2016 and 2024, identifying growth trajectories, structural changes, periods of instability, and variations in profitability. Second, inter-institutional benchmarking compared the entities within each sector using common financial indicators: solvency, leverage, indebtedness, autonomy, profit margin, ROA, and ROE. Third, cross-sector benchmarking compared banking and cooperative profiles through the averages and relative performance of the six institutions included in the study.

For each indicator, the comparison considered measures of central tendency, dispersion, distribution shape, temporal persistence, and volatility. The mean and median represented typical performance; the range and standard deviation measured dispersion; skewness and kurtosis captured asymmetric behavior and extreme observations; and the coefficient of determination from the temporal trend served as an indicator of persistence. The comparative benchmark was calculated from the average results of the six leading institutions analyzed. Each entity and cluster was then interpreted based on whether its performance was above, near, or below this reference. Competitiveness was associated primarily with scale, profitability, and relative efficiency, whereas resilience was assessed through capital autonomy, leverage control, earnings stability, and the capacity to preserve performance during periods of financial stress.

Cluster formation. Cluster analysis was applied separately to banks and cooperatives to prevent the substantial difference in institutional scale between the two sectors from dominating the classification. Each annual institution-year record constituted one analytical observation. The clustering variables included financial magnitudes—assets, liabilities, equity, and net income—and financial ratios—solvency, leverage, indebtedness, autonomy, ROA, and ROE.

Before clustering, variables were reviewed for missing values, unit consistency, and atypical observations. Because financial magnitudes and ratios were expressed on different scales, the variables were standardized using z-scores:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j}$$

In this expression, x_{ij} denotes the value of observation i for variable j , $\bar{x}_j$ denotes the mean of variable j , and s_j denotes its standard deviation. Standardization prevented variables expressed in millions of Colombian pesos from dominating percentage-based indicators.

A k-means clustering algorithm was used to assign each standardized observation to the nearest cluster centroid based on Euclidean distance. Three clusters were retained because this solution provided an appropriate balance between statistical separation, internal cohesion, substantive interpretability, and correspondence with the differentiated financial profiles identified within each institutional sector. Cluster membership was determined by the minimum within-cluster distance, and the final centroids represented the mean standardized profile of the observations assigned to each group.

Cluster validation. The internal validity of the cluster solution was examined using the Silhouette coefficient, which evaluates both the cohesion of each observation within its assigned cluster and its separation from the nearest alternative cluster. For observation i , the coefficient was calculated as:

$$s(i) = \frac{b(i) - a(i)}{\max\{a(i), b(i)\}}$$

where $a(i)$ is the average distance between observation i and the other observations in the same cluster, while $b(i)$ is the lowest average distance between observation i and the observations assigned to the nearest alternative cluster. Values closer to 1 indicate appropriate allocation and clear separation; values close to 0 indicate overlapping profiles; and negative values suggest possible misclassification. Both the overall average coefficient and the distribution of individual Silhouette values were inspected.

External differentiation among clusters was subsequently assessed using one-way ANOVA for each financial indicator. The null hypothesis assumed equality of cluster means, whereas the alternative hypothesis indicated that at least one cluster mean differed. Statistical significance was evaluated at $\alpha = 0.05$. When the omnibus test was significant, the corresponding indicator was interpreted as contributing to cluster differentiation. Given the limited number of institution-year observations and the longitudinal structure of the data, ANOVA results were interpreted as complementary evidence rather than as definitive proof of sector-wide differences.

When the omnibus test was significant, the indicator was interpreted as contributing to the discrimination between clusters. Because the number of observations was limited and the data were longitudinal, ANOVA results were interpreted as complementary evidence rather than definitive proof of sector-wide differences.

RESULTS

The results are presented sequentially and comparatively to show the financial evolution of the six leading institutions analyzed over the 2016–2024 period. First, the financial context of banks and savings and credit cooperatives is described through the behavior of assets, liabilities, equity, and net income. Second, the main indicators of solvency, leverage, indebtedness, autonomy, ROA, and ROE are examined to identify structural strengths, profitability patterns, and episodes of instability. Third, benchmarking and cluster analysis are used to distinguish financial profiles within each institutional group and to assess the tension between competitiveness and resilience. Finally, the comparative analysis integrates the results of banks and cooperatives, highlighting differences in scale, capital structure, profitability, temporal persistence, and capacity to absorb financial shocks.

Financial context of leading banks in the Colombian banking sector

Between 2016 and 2024, the assets, liabilities, equity, and net income of leading banks in Colombia were analyzed. The objective was to identify patterns and trends in their financial performance, evaluate the evolution of key metrics, and assess the factors influencing their behavior.

Table 1 Financial context of leading banks in the Colombian banking sector (2016 – 2024)

BANCOLOMBIA SA (2016 – 2024)				
Year	Assets	Liabilities	Equity	Net Result of the Fiscal Year
Addition	\$2,469,753,463.00	\$2,181,713,863.00	\$288,039,600.00	\$35,646,688.00
Average	\$274,417,051.44	\$242,412,651.44	\$32,004,400.00	\$3,960,743.11
Median	\$255,568,505.00	\$227,453,292.00	\$28,805,619.00	\$3,214,567.00
Range	\$175,954,338.00	\$153,847,043.00	\$22,107,295.00	\$6,681,006.00
Minimum	\$196,261,044.00	\$173,784,064.00	\$22,476,980.00	\$315,359.00
Maximum	\$372,215,382.00	\$327,631,107.00	\$44,584,275.00	\$6,996,365.00
Deviation	\$67,542,578.04	\$59,900,764.33	\$7,726,517.45	\$2,184,847.85
Kurtosis	-\$1.68	-\$1.73	-\$1.24	-\$ 0.73
Asymmetry	\$0.36	\$0.35	\$0.46	-\$ 0.01
Minimum expected	\$71,789,317.33	\$62,710,358.44	\$8,824,847.64	-\$ 2,593,800.44
Expected maximum	\$477,044,785.56	\$422,114,944.45	\$55,183,952.36	\$10,515,286.66
Volatility I/n	\$0.64	\$0.63	\$0.68	\$3.10
r squared value	$R^2 = 0.947$	$R^2 = 0.9453$	$R^2 = 0.9397$	$R^2 = 0.5072$
BANK OF BOGOTA SA (2016 – 2024)				
Year	Assets	Liabilities	Equity	Net Result of the Fiscal Year
Addition	\$1,495,889,426.00	\$1,322,581,231.00	\$173,308,195.00	\$25,300,634.00
Average	\$166,209,936.22	\$146,953,470.11	\$19,256,466.11	\$2,811,181.56
Median	\$150,719,627.00	\$133,877,249.00	\$18,210,221.00	\$2,804,885.00
Range	\$94,860,859.00	\$85,290,911.00	\$9,569,948.00	\$3,904,648.00

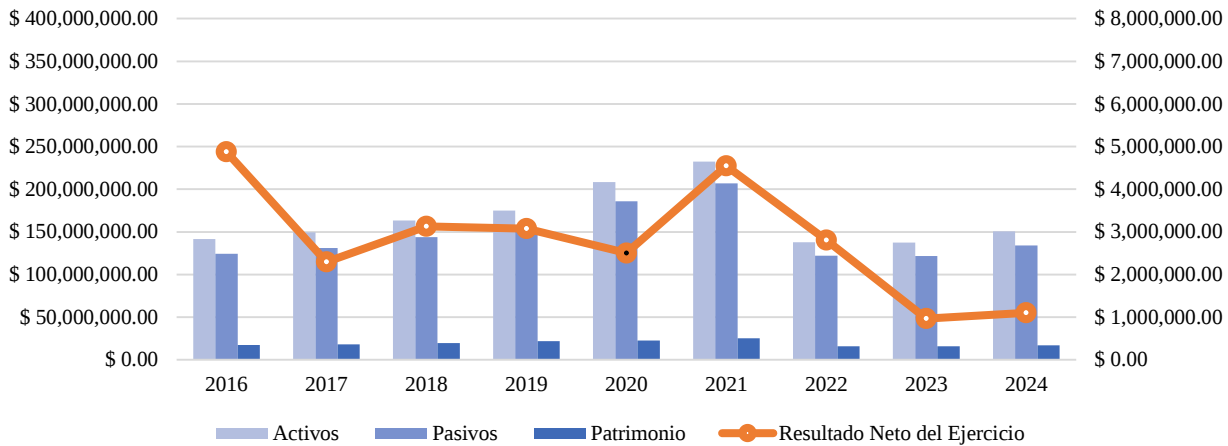
Minimum	\$137,474,036.00	\$121,705,014.00	\$15,769,022.00	\$968,934.00
Maximum	\$232,334,895.00	\$206,995,925.00	\$25,338,970.00	\$4,873,582.00
Deviation	\$33,521,501.28	\$30,323,783.11	\$3,339,179.96	\$1,329,091.79
Kurtosis	\$0.54	\$0.63	-\$0.56	-\$0.50
Asymmetry	\$1.25	\$1.30	\$0.74	\$0.18
Minimum expected	\$65,645,432.37	\$55,982,120.79	\$9,238,926.24	-\$ 1,176,093.83
Expected maximum	\$477,044,785.56	\$422,114,944.45	\$55,183,952.36	\$10,515,286.66
Volatility l/n	\$0.64	\$0.63	\$0.68	\$3.10
r squared value	$R^2 = 0.947$	$R^2 = 0.9453$	$R^2 = 0.9397$	$R^2 = 0.5072$
DAVIVIENDA BANK SA (2016 – 2024)				
Year	Assets	Liabilities	Equity	Net Result of the Fiscal Year
Addition	\$1,270,033,320.00	\$1,150,836,821.00	\$119,196,499.00	\$8,698,744.00
Average	\$141,114,813.33	\$127,870,757.89	\$13,244,055.44	\$966,527.11
Median	\$136,413,365.00	\$123,693,364.00	\$12,720,001.00	\$1,275,266.00
Range	\$97,779,269.00	\$91,663,498.00	\$6,248,331.00	\$2,090,300.00
Minimum	\$93,548,017.00	\$83,502,970.00	\$10,045,047.00	-\$ 372,332.00
Maximum	\$191,327,286.00	\$175,166,468.00	\$16,293,378.00	\$1,717,968.00
Deviation	\$37,206,782.42	\$34,983,846.11	\$2,262,456.39	\$778,038.27
Kurtosis	-\$1.71	-\$1.73	-\$1.38	-\$0.79
Asymmetry	\$0.16	\$0.17	\$0.07	-\$0.95
Minimum expected	\$29,494,466.09	\$22,919,219.55	\$6,456,686.27	-\$ 1,367,587.69
Expected maximum	\$252,735,160.58	\$232,822,296.23	\$20,031,424.62	\$3,300,641.91
Volatility l/n	\$0.64	\$0.63	\$0.68	\$3.10
r squared value	$R^2 = 0.947$	$R^2 = 0.9453$	$R^2 = 0.9397$	$R^2 = 0.5072$

Note: The data presented correspond to the financial analysis of Bancolombia SA, Banco de Bogotá SA, and Banco Davivienda SA for the period 2016–2024, including the sum, average, and other key metrics of their financial statements. All amounts are expressed in millions of Colombian pesos.

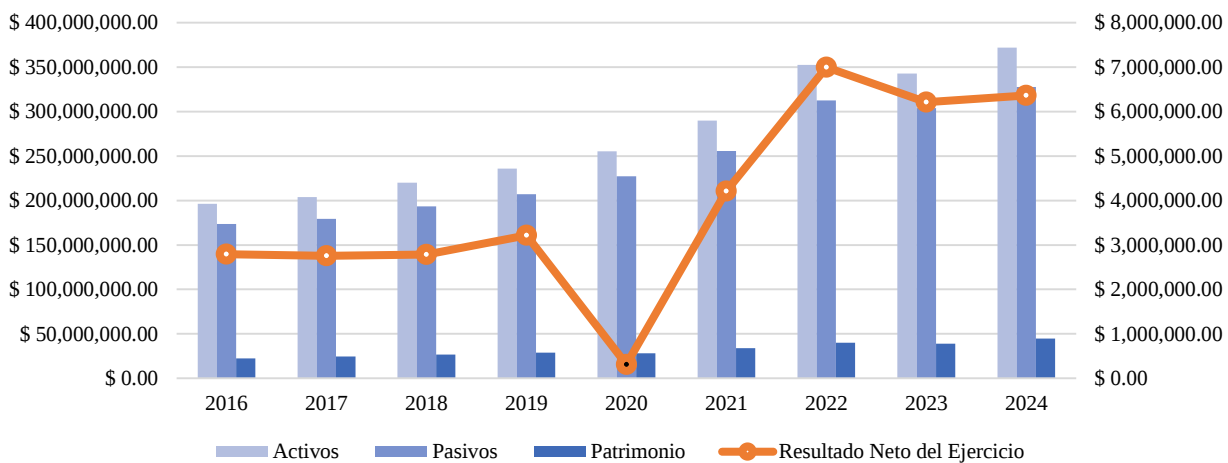
The analysis showed that Bancolombia led in scale and equity, while Banco de Bogotá and Davivienda displayed lower asset levels and more fragile profitability patterns. Although Bancolombia and Davivienda maintained relatively consistent capital structures, earnings volatility and occasional losses weakened their resilience. Overall, benchmarking indicated that greater scale and capitalization did not necessarily ensure stable financial performance. Figure 1 compares the trends in assets, liabilities, equity, and net income of the three banks during 2016–2024.

Figure 1 Financial performance of leading banks in the Colombian banking sector (2016-2024)

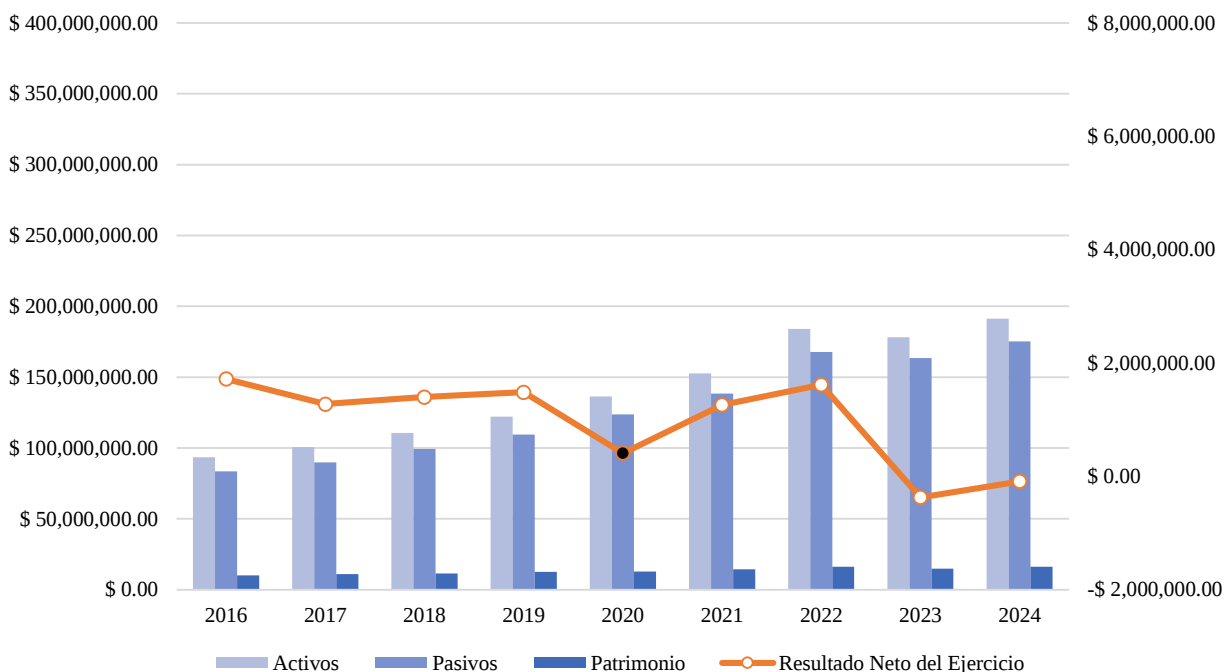
BANK OF BOGOTA



BANCOLOMBIA



DAVIVIENDA BANK



Note: The data presented correspond to the financial performance of Bancolombia, Banco de Bogotá, and Banco

Davivienda during the period 2016–2024, covering their capital structures and net income for the year, as reported in their financial statements. All amounts are expressed in millions of Colombian pesos.

Financial context of leading savings and credit cooperatives in the Colombian cooperative sector

Between 2016 and 2024, the key financial indicators of the main Colombian savings and credit cooperatives were studied, analyzing assets, liabilities, equity and profits to identify trends and causes that affected their economic performance.

Table 2 Financial context of leading savings and credit cooperatives in the Colombian cooperative sector (2016 – 2024)

COOMULTRASAN SAVINGS AND CREDIT COOPERATIVE (2016 – 2024)				
Year	Assets	Liabilities	Equity	Net Result of the Fiscal Year
Addition	\$13,144,563.60	\$8,755,533.25	\$4,389,030.35	\$310,615.82
Average	\$1,460,507.07	\$972,837.03	\$487,670.04	\$34,512.87
Median	\$1,434,797.83	\$969,198.83	\$480,202.23	\$36,884.12
Range	\$762,727.18	\$574,746.76	\$187,980.42	\$39,054.20
Minimum	\$1,118,057.07	\$718,928.39	\$399,128.68	\$7,628.27
Maximum	\$1,880,784.25	\$1,293,675.15	\$587,109.10	\$46,682.47
Deviation	\$260,477.84	\$200,071.26	\$61,526.17	\$12,729.12
Kurtosis	-\$1.05	-\$1.16	-\$0.80	\$1.61
Asymmetry	\$0.28	\$0.29	\$0.17	-\$1.41
Minimum expected	\$679,073.56	\$372,623.25	\$303,091.52	-\$ 3,674.50
Expected maximum	\$2,241,940.57	\$1,573,050.81	\$672,248.55	\$72,700.24
Volatility l/n	\$0.52	\$0.59	\$0.39	\$1.81
r squared value	R ² = 0.9918	R ² = 0.9889	R ² = 0.9655	R ² = 0.031
FINCOMERCIO LTDA SAVINGS AND CREDIT COOPERATIVE (2016 – 2024)				
Year	Assets	Liabilities	Equity	Net Result of the Fiscal Year
Addition	\$6,111,315.03	\$4,701,320.45	\$1,409,994.58	\$85,297.75
Average	\$679,035.00	\$522,368.94	\$156,666.06	\$9,477.53
Median	\$622,929.25	\$470,098.62	\$153,367.28	\$10,033.68
Range	\$553,096.71	\$453,172.06	\$99,924.64	\$12,479.16
Minimum	\$418,835.68	\$311,821.65	\$107,014.03	\$2,714.76
Maximum	\$971,932.39	\$764,993.71	\$206,938.68	\$15,193.92
Deviation	\$193,776.69	\$163,171.67	\$31,212.32	\$4,679.09
Kurtosis	-\$1.39	-\$1.54	-\$0.45	-\$1.58
Asymmetry	\$0.21	\$0.24	\$0.00	-\$0.38
Minimum expected	\$97,704.93	\$32,853.93	\$63,029.09	-\$ 4,559.74
Expected maximum	\$1,260,365.08	\$1,011,883.94	\$250,303.03	\$23,514.80
Volatility l/n	\$0.84	\$0.90	\$0.66	\$1.72
r squared value	R ² = 0.9746	R ² = 0.9666	R ² = 0.9783	R ² = 0.131
CREDISERVIR LTDA SAVINGS AND CREDIT COOPERATIVE (2016 – 2024)				
Year	Assets	Liabilities	Equity	Net Result of the Fiscal Year
Addition	\$5,760,961.41	\$3,694,122.65	\$2,066,838.76	\$119,676.20
Average	\$640,106.82	\$410,458.07	\$229,648.75	\$13,297.36
Median	\$621,881.24	\$396,599.72	\$225,281.53	\$13,753.42
Range	\$518,167.52	\$361,418.33	\$156,749.19	\$19,274.76
Minimum	\$418,274.58	\$268,613.41	\$149,661.17	\$4,651.11
Maximum	\$936,442.10	\$630,031.74	\$306,410.36	\$23,925.87
Deviation	\$164,158.32	\$114,042.84	\$51,195.33	\$7,597.04
Kurtosis	-\$ 0.31	\$0.19	-\$0.85	-\$1.84
Asymmetry	\$0.47	\$0.72	-\$0.05	\$0.23
Minimum expected	\$147,631.88	\$68,329.54	\$76,062.77	-\$9,493.76
Expected maximum	\$1,132,581.77	\$752,586.60	\$383,234.74	\$36,088.47

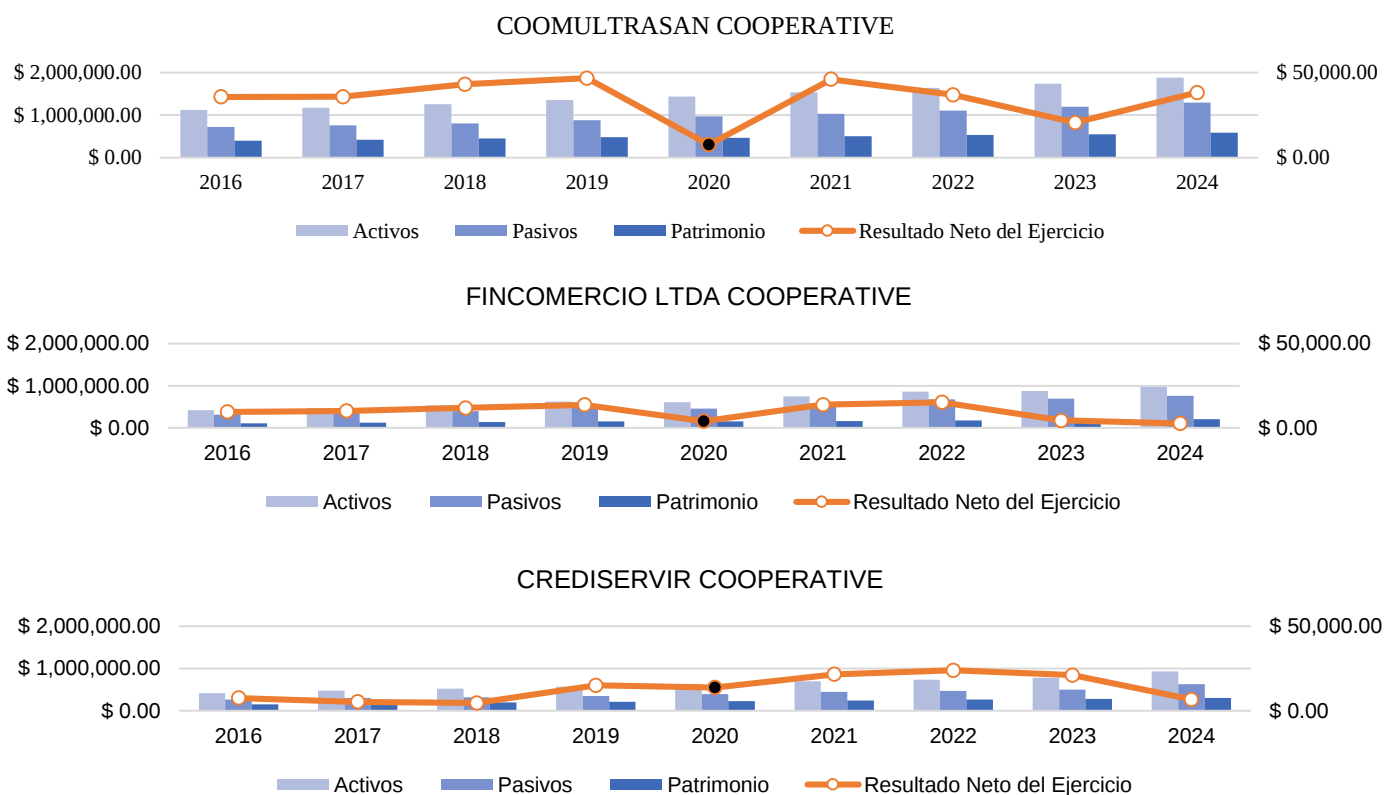
Volatility I/n	\$0.81	\$0.85	\$0.72	\$1.64
r squared value	$R^2 = 0.9707$	$R^2 = 0.942$	$R^2 = 0.9945$	$R^2 = 0.2848$

Note: The data presented correspond to the financial analysis of Coomultrasan, Fincomercio, and Crediservir for the period 2016–2024, including the sum, average, and other key metrics from their financial statements. All amounts are expressed in millions of Colombian pesos.

The analysis showed that Coomultrasan maintained solid asset and equity growth with high temporal consistency ($R^2 > 0.96$), although its profitability exhibited high volatility (1.81), which limited its resilience. Fincomercio showed stable capitalization ($R^2 > 0.96$) and predictable equity behavior, but with fluctuating profits that reduced its capacity to absorb external shocks. In the case of Crediservir, strong consistency in assets and equity was observed ($R^2 \approx 0.99$), whereas net results were unstable ($R^2 = 0.28$) and dependent on cyclical events, reflecting limited resilience. From a benchmarking perspective, the three cooperatives were competitive in asset consolidation but showed weaknesses in resilience, failing to sustain consistent profitability. This finding indicated that structural competitiveness did not automatically translate into stable results, highlighting the need for diversification and risk management strategies.

The following is a graphical comparison of the financial results (2016-2024) of Coomultrasan, Fincomercio and Crediservir, highlighting trends in assets, liabilities, equity and results.

Figure 2 Financial performance of leading savings and credit cooperatives in the Colombian cooperative sector (2016-2024)



Note: The data presented correspond to the financial performance of Coomultrasan, Fincomercio, and Crediservir during the period 2016–2024, covering trends in their capital structures and net results for the fiscal year, based on financial information reported to the Superintendency of the Solidarity Economy in Colombia. All amounts are expressed in millions of Colombian pesos.

Descriptive analysis of the financial management indicators of leading banks in the Colombian banking sector (2016–2024)

Between 2016 and 2024, a descriptive analysis of the financial management indicators of leading Colombian banks was conducted. Table 3 summarizes the main findings, highlighting strength, leverage, profitability, and other key metrics.

Table 3 Financial management indicators of leading banks in the Colombian banking sector (2016–2024)

BANCOLOMBIA SA (2016 – 2024)						
Year	Solidity	Leverage	Indebtedness	Autonomy	ROA	ROE
Addition	\$10.19	\$68.12	794.85%	105.15%	12.48%	106.52%
Average	\$1.13	\$7.57	88.32%	11.68%	1.39%	11.84%
Median	\$1.13	\$7.54	88.30%	11.70%	1.42%	12.40%
Range	\$0.02	\$0.89	1.20%	1.20%	1.86%	16.37%
Minimum	\$1.12	\$7.20	87.80%	11.00%	0.12%	1.12%
Maximum	\$1.14	\$8.09	89.00%	12.20%	1.98%	17.49%
Deviation	\$0.01	\$0.30	0.41%	0.41%	0.53%	4.65%
Kurtosis	-\$1.20	-\$ 1.01	-117.74%	-117.74%	455.67%	376.78%
Asymmetry	-\$0.29	\$0.39	30.03%	-30.03%	-181.53%	-155.20%
Minimum expected	\$1.12	\$6.66	87.08%	10.45%	-0.21%	-2.11%
Expected maximum	\$1.15	\$8.48	89.55%	12.92%	2.98%	25.78%
Volatility l/n	\$0.01	\$0.12	1.36%	10.35%	277.70%	274.69%
r squared value	R² = 0.0367	R² = 0.035	R² = 0.0365	R² = 0.0365	R² = 0.1216	R² = 0.1298
BANK OF BOGOTA SA (2016 – 2024)						
Year	Solidity	Leverage	Indebtedness	Autonomy	ROA	ROE
Addition	\$10.19	\$68.50	795.22%	104.78%	15.28%	130.24%
Average	\$1.13	\$7.61	88.36%	11.64%	1.70%	14.47%
Median	\$1.13	\$7.72	88.53%	11.47%	1.76%	14.06%
Range	\$0.02	\$1.25	1.69%	1.69%	2.74%	22.01%
Minimum	\$1.12	\$7.01	87.51%	10.80%	0.70%	6.14%
Maximum	\$1.14	\$8.26	89.20%	12.49%	3.44%	28.15%
Deviation	\$0.01	\$0.46	0.62%	0.62%	0.83%	6.70%
Kurtosis	-\$1.64	-\$1.60	-164.14%	-164.14%	184.40%	130.06%
Asymmetry	-\$ 0.03	\$0.14	3.84%	-3.84%	95.65%	81.04%
Minimum expected	\$1.11	\$6.24	86.50%	9.79%	-0.78%	-5.64%
Expected maximum	\$1.16	\$8.99	90.21%	13.50%	4.18%	34.58%
Volatility l/n	\$0.02	\$0.16	1.91%	14.51%	158.66%	152.21%
r squared value	R² = 0.457	R² = 0.4364	R² = 0.4548	R² = 0.4548	R² = 0.508	R² = 0.449
DAVIVIENDA BANK SA (2016 – 2024)						
Year	Solidity	Leverage	Indebtedness	Autonomy	ROA	ROE
Addition	\$9.96	\$85.57	813.56%	86.44%	7.33%	71.68%
Average	\$1.11	\$9.51	90.40%	9.60%	0.81%	7.96%
Median	\$1.10	\$9.69	90.65%	9.35%	0.88%	9.92%
Range	\$0.03	\$2.82	2.52%	2.52%	2.05%	19.63%
Minimum	\$1.09	\$8.26	89.20%	8.28%	-0.21%	-2.52%

DAVIVIENDA BANK SA (2016 – 2024)						
Solidity	Leverage	Indebtedness	Autonomy	ROA	ROE	
Maximum	\$1.12	\$11.08	91.72%	10.80%	1.84%	17.10%
Deviation	\$0.01	\$1.08	0.97%	0.97%	0.68%	6.52%
Kurtosis	-\$1.75	-\$1.59	-174.01%	-174.01%	-85.65%	-77.29%

Asymmetry	-\$ 0.06	\$0.25	7.69%	-7.69%	-27.39%	-53.59%
Minimum expected	\$1.07	\$6.27	87.48%	6.69%	-1.22%	-11.59%
Expected maximum	\$1.14	\$12.74	93.31%	12.52%	2.85%	27.52%
Volatility l/n	\$0.03	\$0.29	2.79%	26.60%	#NUM!	#NUM!
r squared value	R ² = 0.9377	R ² = 0.9305	R ² = 0.9375	R ² = 0.9375	R ² = 0.7817	R ² = 0.7169

Note. Table 3 presents key financial management indicators for leading banks in Colombia between 2016 and 2024, using descriptive statistics, including soundness, leverage, indebtedness, autonomy, ROA, and ROE.

An analysis of leading banks in Colombia between 2016 and 2024 showed that Bancolombia, Banco de Bogotá, and Davivienda shared relatively stable capital structures, although they differed in competitiveness and resilience. Bancolombia demonstrated strong equity and stability in both capital adequacy and leverage, but its profitability proved highly volatile, limiting its resilience. Banco de Bogotá recorded higher profitability levels (ROA and ROE), though with low consistency over time, indicating vulnerability to external shocks. Davivienda had the lowest average profitability but greater relative consistency in its trends, though its high leverage reflected greater structural vulnerability.

Overall, the benchmarking revealed that the financial competitiveness of leading banks did not automatically translate into resilience. While Bancolombia and Bogotá stood out for their size and profitability, their sustainability was uncertain, and Davivienda, despite its lower profitability, showed greater relative stability in its trends. These findings confirmed that resilience remained under pressure from competitiveness and was contingent on risk-management capacity and external economic factors.

Descriptive analysis of the financial management indicators of leading cooperatives in the Colombian solidarity sector (2016–2024)

Between 2016 and 2024, a descriptive analysis of the financial management indicators of leading cooperatives in the Colombian solidarity sector was conducted. Data on solvency, leverage, indebtedness, autonomy, ROA, and ROE were examined to identify relevant trends and patterns in their performance.

Table 4 Financial management indicators of leading cooperatives in the Colombian solidarity sector (2016–2024)

COOMULTRASAN SAVINGS AND CREDIT COOPERATIVE (2016 – 2024)						
Year	Solidity	Leverage	Indebtedness	Autonomy	ROA	ROE
Addition	\$13.58	\$17.80	596.91%	303.09%	22.09%	64.70%
Average	\$1.51	\$1.98	66.32%	33.68%	2.45%	7.19%
Median	\$1.48	\$2.06	67.35%	32.65%	3.00%	8.55%
Range	\$0.11	\$0.43	4.80%	4.80%	2.91%	8.08%
Minimum	\$1.45	\$1.78	63.99%	31.22%	0.53%	1.64%
Maximum	\$1.56	\$2.20	68.78%	36.01%	3.44%	9.72%

Deviation	\$0.04	\$0.17	1.95%	1.95%	1.04%	2.83%
Kurtosis	-\$2.18	-\$2.08	-214.86%	-214.86%	-28.91%	40.78%
Asymmetry	\$0.10	-\$ 0.02	-7.49%	7.49%	-94.91%	-119.07%
Minimum expected	\$1.38	\$1.46	60.46%	27.82%	-0.66%	-1.30%
Expected maximum	\$1.64	\$2.50	72.18%	39.54%	5.57%	15.67%
Volatility l/n	\$0.07	\$0.22	7.23%	14.30%	186.64%	178.06%
r squared value	R ² = 0.8581	R ² = 0.8678	R ² = 0.8615	R ² = 0.8615	R ² = 0.3277	R ² = 0.2338

FINCOMERCIO LTDA SAVINGS AND CREDIT COOPERATIVE (2016 – 2024)						
Year	Solidity	Leverage	Indebtedness	Autonomy	ROA	ROE
Addition	\$11.79	\$29.44	687.51%	212.49%	13.88%	57.82%
Average	\$1.31	\$3.27	76.39%	23.61%	1.54%	6.42%
Median	\$1.33	\$3.08	75.47%	24.53%	1.85%	8.42%

Range	\$0.09	\$0.98	5.31%	5.31%	1.99%	7.64%
Minimum	\$1.26	\$2.83	73.90%	20.79%	0.28%	1.31%
Maximum	\$1.35	\$3.81	79.21%	26.10%	2.27%	8.96%
Deviation	\$0.04	\$0.41	2.25%	2.25%	0.82%	3.26%
Kurtosis	-\$2.25	-\$2.23	-225.31%	-225.31%	-150.67%	-150.06%
Asymmetry	-\$0.19	\$0.27	21.19%	-21.19%	-76.17%	-87.99%
Minimum expected	\$1.19	\$2.03	69.64%	16.86%	-0.91%	-3.35%
Expected maximum	\$1.43	\$4.51	83.14%	30.36%	3.99%	16.20%
Volatility l/n	\$0.07	\$0.30	6.95%	22.77%	209.67%	192.09%
r squared value	R ² = 0.8192	R ² = 0.8121	R ² = 0.8179	R ² = 0.8179	R ² = 0.6152	R ² = 0.453
CREDISERVIR LTDA SAVINGS AND CREDIT COOPERATIVE (2016 – 2024)						
Year	Solidity	Leverage	Indebtedness	Autonomy	ROA	ROE
Addition	\$14.10	\$15.96	574.93%	325.07%	18.44%	50.91%
Average	\$1.57	\$1.77	63.88%	36.12%	2.05%	5.66%
Median	\$1.57	\$1.76	63.77%	36.23%	2.21%	6.10%
Range	\$0.13	\$0.43	5.34%	5.34%	2.54%	6.80%
Minimum	\$1.49	\$1.63	61.94%	32.72%	0.71%	2.18%
Maximum	\$1.61	\$2.06	67.28%	38.06%	3.26%	8.98%
Deviation	\$0.04	\$0.13	1.56%	1.56%	0.96%	2.65%
Kurtosis	\$2.23	\$3.31	259.39%	259.39%	-164.81%	-162.72%
Asymmetry	-\$0.97	\$1.41	112.58%	-112.58%	-24.72%	-19.27%
Minimum expected	\$1.45	\$1.40	59.20%	31.44%	-0.84%	-2.30%
Expected maximum	\$1.68	\$2.15	68.56%	40.80%	4.94%	13.61%
Volatility l/n	\$0.08	\$0.23	8.28%	15.13%	152.03%	141.68%
r squared value	R ² = 0.3286	R ² = 0.3397	R ² = 0.333	R ² = 0.333	R ² = 0.0683	R ² = 0.0828

Note. Table 4 presents the financial management indicators of leading cooperatives in Colombia (2016-2024), using descriptive statistical measures, including solvency, leverage, indebtedness, autonomy, ROA and ROE.

The analysis of the cooperatives Coomultrasan, Fincomercio, and Crediservir between 2016 and 2024 showed solid and stable capital structures, but with significant tensions between competitiveness and resilience. Coomultrasan presented an average capital strength of 1.51 and autonomy of 33.68%, with a return on assets (ROA) of 2.45% and an return on equity (ROE) of 7.19%. These results confirmed its competitive capacity in terms of capitalization, but the volatility in profitability (ROA 186.64% and ROE 178.06%) reduced its resilience. Fincomercio reflected higher leverage (3.27) and indebtedness of 76.39%, which limited its autonomy (23.61%). Although it achieved an ROE of 6.42%, its instability was marked by volatilities exceeding 190%, demonstrating vulnerability to external shocks. Crediservir stood out for its greater strength (1.57) and autonomy (36.12%), with contained debt (63.88%) and a ROA of 2.05%. However, its returns were also unstable (ROA volatility of 152.03% and ROE of 141.68%), indicating that equity competitiveness did not translate into sustained resilience.

From a benchmarking perspective, the comparison revealed that cooperatives achieved financial competitiveness through high levels of capitalization and structural stability, but their resilience was strained by their inability to sustain consistent profitability. This finding suggested that strong equity, while necessary, was insufficient to guarantee resilience in the face of volatile results.

Clustering and benchmarking of leading banks in Colombia (2016–2024)

Based on panel data from Bancolombia, Banco de Bogotá, and Davivienda, a clustering analysis was performed using 27 institution-year observations, corresponding to three banks observed annually from 2016 to 2024. These observations were assigned to three clusters with distinct financial profiles. The assignment was based on proximity to centroids calculated for magnitudes (assets, liabilities, equity, and net income) and performance/structure ratios (financial strength, leverage, indebtedness, autonomy, ROA, and ROE). Model

validation was carried out by inspecting the Silhouette plot and comparing centroids, and was complemented by one-way ANOVA to compare means between clusters for each indicator.

Cluster 1 – “High scale, volatile profitability”.

The years characterized by high magnitudes and a stable structure were concentrated, dominated by Bancolombia. Its assets averaged \$274.4 trillion (SD \$67.5 trillion) and liabilities \$242.4 trillion (SD \$59.9 trillion), with high R^2 values for assets, liabilities, and equity (0.947, 0.945, and 0.940), demonstrating consistent trends. In terms of ratios, strength remained at 1.13 and leverage at 7.57, with low dispersion (SDs of 0.01 and 0.30). Tension appeared in profitability: ROA 1.39% and ROE 11.84% with very high log volatilities (277.7% and 274.7%) and modest R^2 values (0.122 and 0.130). Positive kurtosis in profitability (occasional peaks) and negative skewness (occasional drops) indicated that competitiveness by scale did not always translate into profitability resilience.

Cluster 2 – “Medium-high profitability, trend not very persistent”.

Years with relatively higher ROA and ROE (1.70% and 14.47%) predominated for Banco de Bogotá, but these results showed low temporal persistence. In terms of magnitude, assets averaged COP 166.2 trillion (SD COP 33.5 trillion) and liabilities COP 147.0 trillion (SD COP 30.3 trillion). The structure (strength 1.13; leverage 7.61) was comparable to that of Bancolombia, but the R^2 values for magnitude and endowment/autonomy were very low (≤ 0.457), indicating erratic trajectories. The volatility of ROA/ROE (SDs of 0.83 and 6.70; log volatilities of 158.7% and 152.2%) suggested sensitivity to shocks. The cluster reflected profitability and competitiveness, but resilience was strained due to the absence of a robust trend.

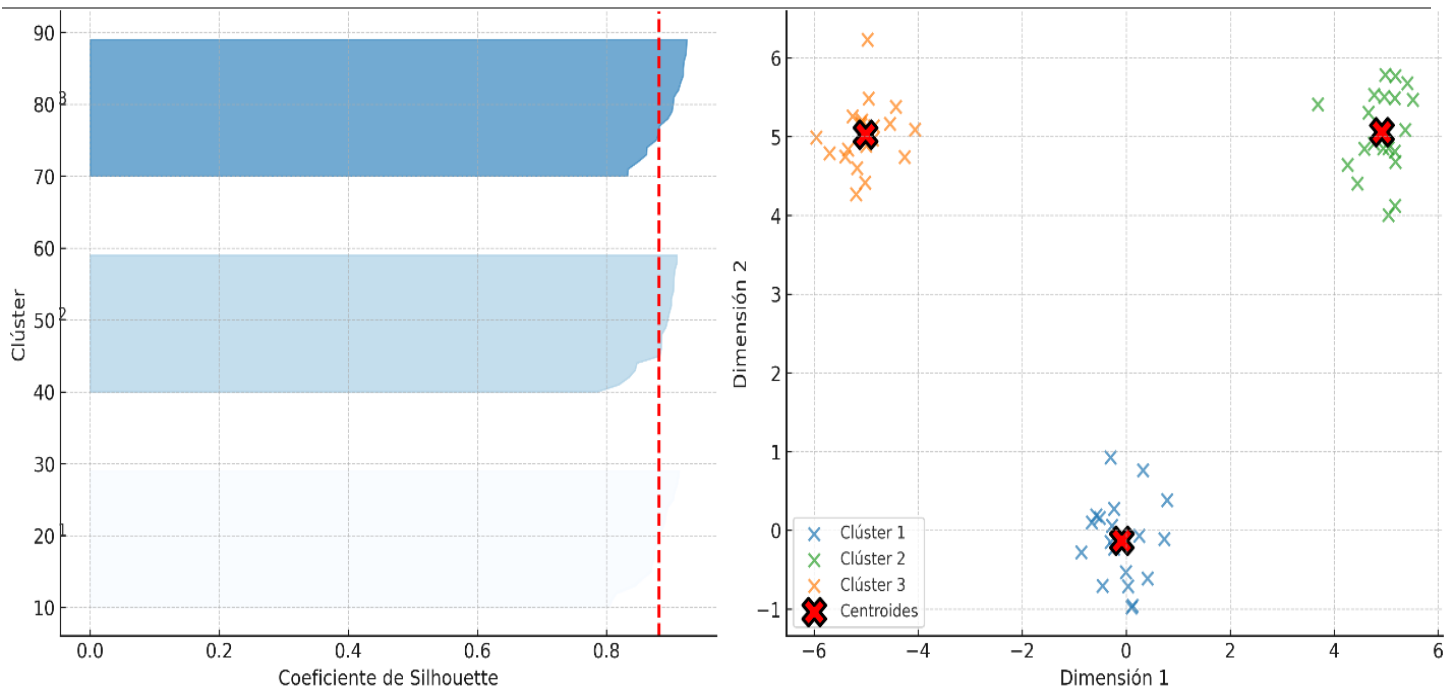
Cluster 3 – “High leverage, relative structural consistency”.

The years were primarily those of Davivienda, with higher leverage (9.51), higher indebtedness (90.40%), and lower autonomy (9.60%). Despite this, the magnitudes showed very high R^2 values (assets: 0.965; liabilities: 0.966; equity: 0.917), demonstrating consistency in the growth path. In terms of profitability, lower averages (ROA 0.81%; ROE 7.96%) and negative episodes (minimum result -\$372 billion) revealed vulnerability; however, the time-dependent explanation of profitability was greater than in the other banks (R^2 ROA 0.782; ROE 0.717), suggesting a less random dynamic, although constrained by leverage.

Validation and robustness of the model.

The Silhouette plot showed appreciable separation and sufficient internal cohesion among the three groups, as evidenced by well-differentiated centroids across scale (assets/liabilities), structure (strength/leverage/debt/autonomy), and profitability (ROA/ROE). One-way ANOVA at the indicator level revealed statistically significant differences ($\alpha = 0.05$) in leverage, debt/autonomy, and ROE, which acted as first-order discriminant variables. Assets and liabilities also discriminated by scale, while ROA helped to separate resilience profiles in the presence of shocks. Overall, the validation confirmed that the segmentation captured financial patterns consistent with the theory: scale and leverage separated competitiveness, while volatility and persistence (R^2) modulated resilience.

Figure 3 Validation and robustness of the clustering and benchmarking model of leading banks in Colombia (2016–2024)



Note. Figure 3 illustrates cluster validation using the Silhouette method and shows the distribution of clusters and centroids of leading banks in Colombia from 2016 to 2024. Three distinct clusters were identified, and the Silhouette plot indicates the quality of the clustering.

Reading in terms of competitiveness vs. resilience.

1. Cluster 1 showed that the advantage of scale (Bancolombia) coexists with volatile profits; competitiveness was high, but resilience was compromised by shocks that affected ROA/ROE.
2. Cluster 2 showed medium-high profitability (Banco de Bogotá) with inconsistent trajectories; the sustainability of the results was conditioned by circumstances, which weakened intertemporal resilience.
3. Cluster 3 noted that high leverage (Davivienda) allowed for consistency of scale, but restricted the capacity to absorb losses, maintaining resilience under pressure despite high R^2 values.

Implications of benchmarking.

When comparing centroids, the banking system exhibited three benchmark frontiers: (i) scale/structural stability with fragile profitability (Cluster 1); (ii) higher profitability with weak persistence (Cluster 2); and (iii) growth consistency conditioned by leverage (Cluster 3). In terms of competitiveness, scale and ROE dominated; in terms of resilience, profit volatility and autonomy proved decisive. Benchmarking suggested specific improvement paths:

- For Cluster 1 type profiles: smooth out ROA/ROE volatility (countercyclical provisioning policies, income diversification).
- For Cluster 2 type profiles: anchor persistence (cost discipline and portfolio quality) to sustain profitability.
- For Cluster 3 type profiles: reduce effective leverage and strengthen autonomy to expand shock absorption capacity.

Cluster analysis showed that financial competitiveness (scale, effective leverage, ROE) alone did not guarantee resilience. The persistence of trends (R^2), earnings volatility, and capital adequacy distinguished banks with apparent strength from those with effective stability amid shocks. Therefore, the optimal financial policy was

framed within a compromise frontier that maintained scale and profitability without sacrificing capital buffers and intertemporal stability.

Clustering and benchmarking of leading cooperatives in Colombia (2016–2024)

Based on panel statistics from Coomultrasan, Fincomercio, and Crediservir, a clustering analysis was performed, assigning the 27 annual observations to three clusters with distinct financial profiles. The assignment was based on proximity to centroids calculated for magnitudes (assets, liabilities, equity, and net income) and performance/structure ratios (financial strength, leverage, indebtedness, autonomy, ROA, and ROE). Validation was carried out using Silhouette plots and centroid comparisons, complemented by one-way ANOVA to compare means between clusters for each indicator.

Cluster 1 – “Robust equity, volatile returns”

This group was primarily composed of Coomultrasan. Its assets averaged \$1.46 trillion (SD \$260.478 billion) and its equity \$487.670 billion (SD \$61.526 billion). The structure exhibited high R^2 (assets 0.992; liabilities 0.989; equity 0.966), reflecting consistent growth. However, net income showed volatility (mean \$34.513 billion; range \$39.054 billion), with average ROA of 2.45% and ROE of 7.19%, both of which were highly dispersed. Competitiveness was based on scale and equity, although resilience was compromised by earnings shocks.

Cluster 2 – “Conservative profile, limited returns”

Observations related to Fincomercio predominated. Its assets averaged \$679,035 million (SD \$193,777 million) and its equity \$156,666 million, with modest net income (average \$9,478 million). Average debt reached 76.39%, accompanied by an equity ratio of only 23.61%. Statistical validation showed R^2 values between 0.812 and 0.978, indicating consistent trends, but profitability was low (ROA 1.54%, ROE 6.42%) and log volatility was high (209.7% and 192.1%). This profile demonstrated conservative stability but limited competitiveness due to low returns and low resilience under prolonged stress.

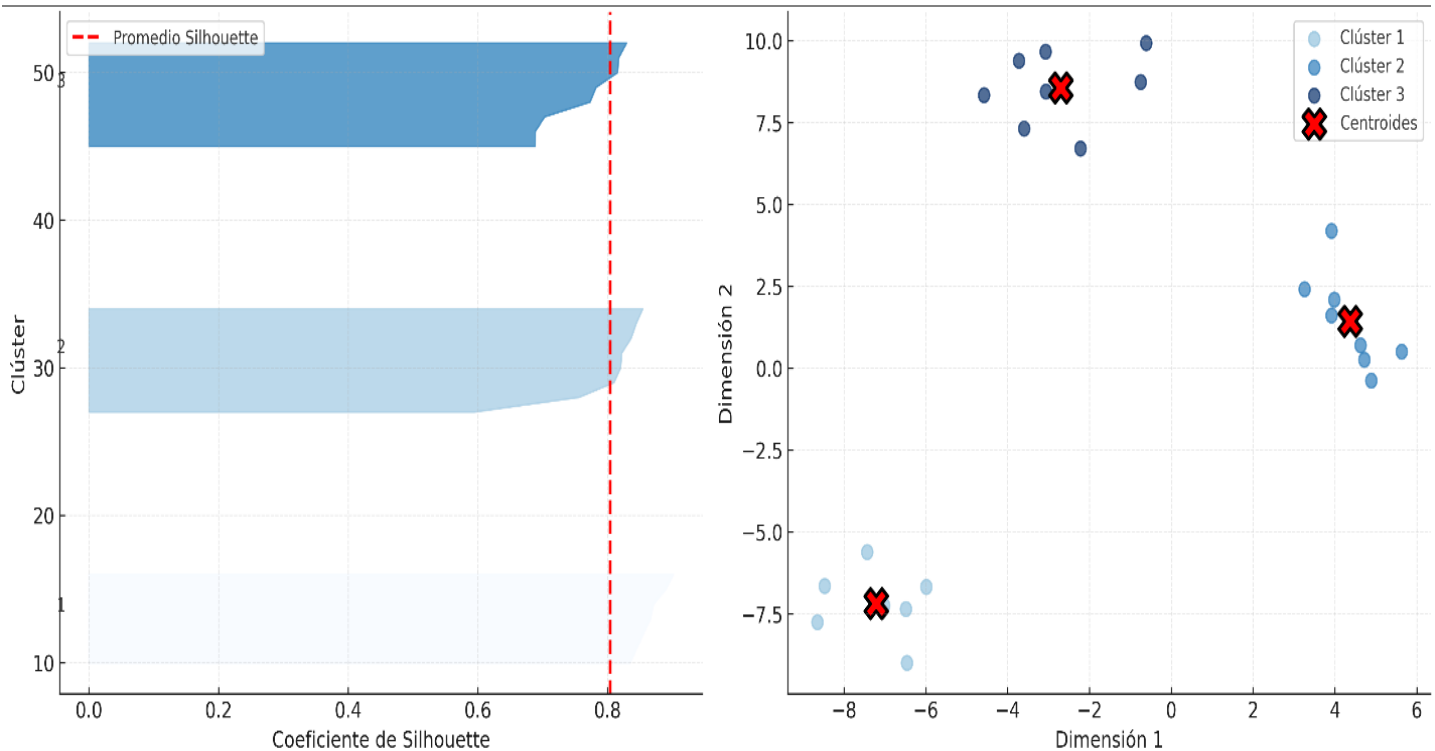
Cluster 3 – “High stability, shock-sensitive profitability”

This cluster primarily included observations from Crediservir. Assets averaged \$640,107 million (SD \$164,158 million) and equity \$229,649 million, with an average solvency ratio of 1.57 and leverage of 1.77. Autonomy (36.12%) outperformed its peers, reinforcing the structural base. However, the R^2 for profitability was low (ROA 0.068; ROE 0.083), indicating sensitivity to external shocks. The average ROA of 2.05% and ROE of 5.66% reflected positive returns but with inconsistent trajectories, weakening resilience in high-volatility environments.

Validation and robustness of the model

The Silhouette plot showed appreciable separation and acceptable internal cohesion among the clusters. The centroids clearly discriminated between (i) equity scale and asset size (Coomultrasan), (ii) a conservative, low-return profile (Fincomercio), and (iii) greater structural strength with volatile profitability (Crediservir). The one-way ANOVA at the indicator level verified statistically significant differences ($\alpha = 0.05$) in autonomy, leverage, and ROE, confirming that these were the factors with the greatest discriminating power.

Figure 4 Validation and robustness of the clustering and benchmarking model of leading cooperatives in Colombia (2016–2024)



Note. Figure 4 illustrates cluster validation using the Silhouette method and shows the distribution of clusters and centroids of leading banks in Colombia from 2016 to 2024. Three distinct clusters were identified, and the Silhouette plot indicates the quality of the clustering.

A reading in terms of competitiveness vs. resilience

1. **Cluster 1 (Coomultrasan):** showed equity advantage and significant scale, although competitiveness was weakened by ROA/ROE volatility, which compromised its resilience to revenue shocks.
2. **Cluster 2 (Fincommerce):** was characterized by reduced returns and a conservative structure; competitiveness was limited, and resilience depended on maintaining low levels of risk rather than generating sustained profits.
3. **Cluster 3 (Crediservir):** exhibited structural strength and relative autonomy, but volatility in profitability revealed fragility in the face of external stresses, which posed a challenge to consolidate intertemporal resilience.

Implications of benchmarking

When comparing centroids, the cooperative sector presented three reference frontiers: (i) robust equity with unstable profits (Cluster 1), (ii) conservative stability with reduced returns (Cluster 2), and (iii) structural soundness with inconsistent profitability (Cluster 3). In terms of competitiveness, scale and autonomy were key factors, while resilience depended on the consistency of results and the capacity to absorb shocks.

Comparative financial context: leading banks and savings and credit cooperatives in Colombia

To characterize the financial profiles resulting from clustering, a table of centroids and key metrics was constructed for banks and cooperatives for the period 2016–2024. This synthesis revealed how each cluster reflected a distinct balance between financial competitiveness, expressed in scale, leverage, and profitability, and resilience under stress, associated with capital adequacy, time persistence (R^2), and shock absorption capacity. Furthermore, a sector average was incorporated as a benchmark to anchor the comparison between the two groups of entities.

Table 5 Comparative financial context: leading banks and savings and credit cooperatives in Colombia

Cluster / Profile (dominant entity)	Assets (average)	Leverage	Indebtedness	Autonomy	ROA	ROE	Persistence size (active R ²)
B1 – High scale, volatile profitability (Bancolombia)	274,417,051	7.57×	88.32%	11.68%	1.39%	11.84%	0.947
B2 – Medium-high profitability, trend not very persistent (Banco de Bogotá)	166,209,936	7.61×	88.36%	11.64%	1.70%	14.47%	0.0001
B3 – High leverage, consistent scale (Davivienda)	141,114,813	9.51×	90.40%	9.60%	0.81%	7.96%	0.9649
C1 – Relatively high capitalization, controlled risk (Coomultrasan)	1,460,507	1.98×	66.32%	33.68%	2.45%	7.19%	0.9918
C2 – Average leverage, conditional efficiency (Fincommerce)	679,035	3.27×	76.39%	23.61%	1.54%	6.42%	0.9746
C3 – High autonomy, medium scale (Crediservir)	640,107	1.77×	63.88%	36.12%	2.05%	5.66%	0.9707
Sector benchmark (averages of 6 entities)	97,420,242	5.285×	78.95%	21.06%	1.66%	8.92%	—

Note. Table 5 presents a comparative financial context between leading banks and cooperatives in Colombia, highlighting key indicators such as assets, ROE, and leverage.

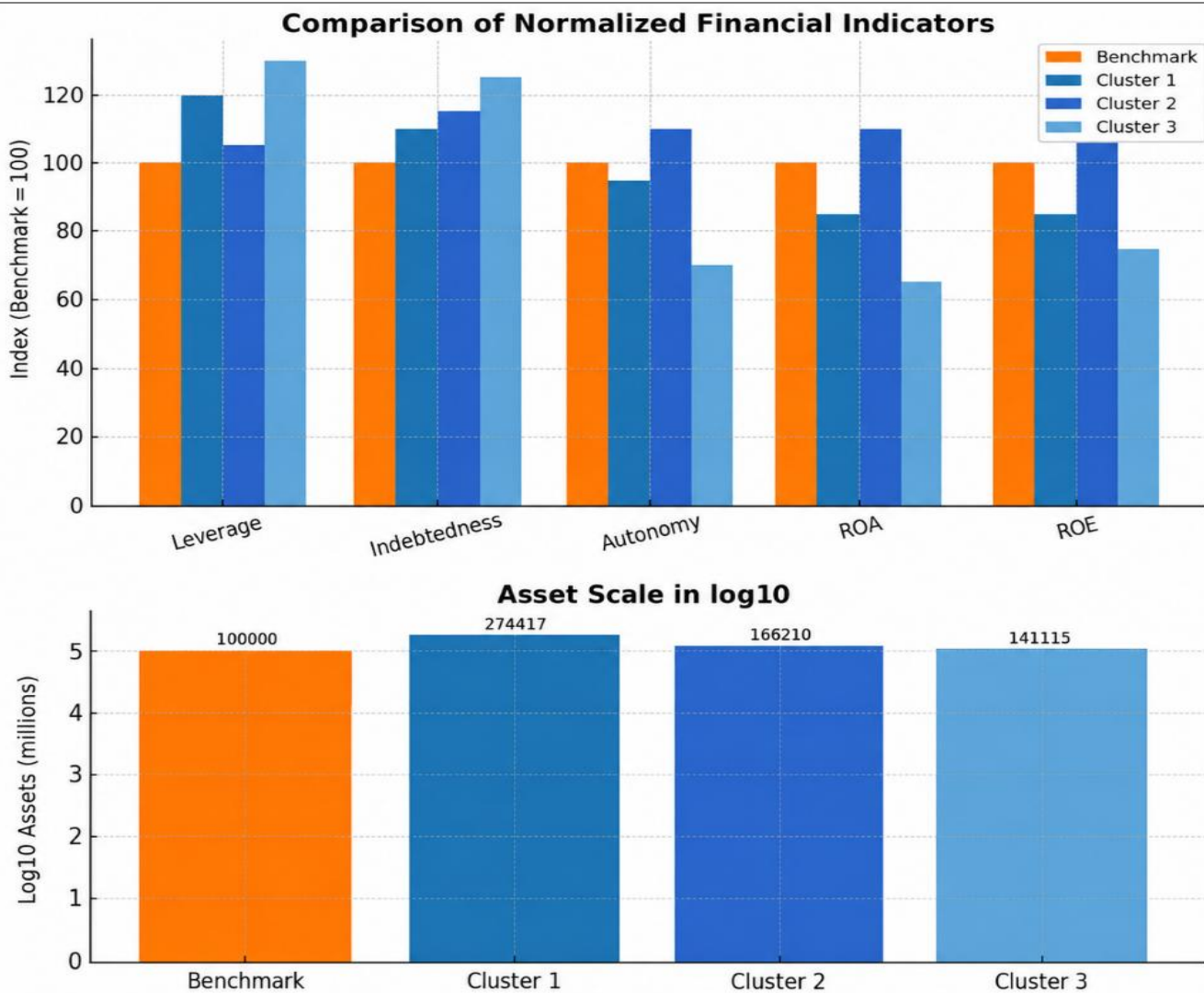
In terms of scale, banks clustered in assets exceeding \$140 billion, granting them volume advantages, albeit at the cost of highly leveraged structures (7.57x-9.51x) and reduced autonomy (9–12%). Cooperatives, in contrast, operated with smaller assets but with relatively stronger capital bases. Coomultrasan and Crediservir stood out, achieving autonomy of 34% and 36%, respectively, thus consolidating profiles with greater financial flexibility.

Regarding profitability, banks led in ROE, with Banco de Bogotá at 14.47%, although with low temporal persistence ($R^2 \approx 0.0001$), suggesting results subject to market fluctuations. Cooperatives, despite lower returns on equity (5–7%), achieved better ROA, with 2.45% at Coomultrasan and 2.05% at Crediservir, reflecting more efficient use of their assets. The sector benchmark showed an average leverage of 5.28x and autonomy of 21%, consistently placing banks higher in debt and lower in autonomy, while cooperatives remained in the opposite position. The average ROE (8.92%) was primarily driven by banks, while the ROA (1.66%) reflected the differential contribution of the more efficient cooperatives. This contrast confirmed that financial competitiveness did not depend exclusively on size but also on capital structure and resilience, aspects in which cooperatives exhibited comparative advantages over the most-leveraged banks.

Implications for competitiveness and resilience

1. Competitiveness: In banks, the profitability advantage was concentrated in Cluster 2 (Banco de Bogotá), although there were no conclusive differences in ROE. In cooperatives, competitiveness was explained more by capital strength and autonomy (Crediservir) or by a balance between scale and profitability (Coomultrasan).
2. Resilience under stress: Contrasts in leverage and autonomy were the main differentiating factors. Among the cooperatives, the banking Cluster 3 (Davivienda) and Fincomercio showed greater ex-ante vulnerability due to their high debt levels.
3. Benchmarking: To improve their performance frontier, clusters had to increase autonomy without compromising ROA/ROE efficiency. In banks, this meant containing leverage in Cluster 3 and consolidating profitability in Cluster 2; in cooperatives, it meant capitalizing on profiles like those of Crediservir and Coomultrasan, which combined greater capital adequacy with stable returns.

Figure 5 Comparative financial context: leading banks and savings and credit cooperatives in Colombia



Note. Figure 5 compares normalized financial indicators and asset scale (in log10) between leading banks and cooperatives in Colombia relative to a sector benchmark.

DISCUSSION

The results obtained in this study allowed for a direct comparison of empirical evidence from the Colombian financial system with the theoretical frameworks identified in the state of the art. First, the findings on differences in scale and leverage between banks and cooperatives confirmed agency theory's predictions regarding the costs associated with control and capital structure (Dwekat et al., 2025; Figueira et al., 2009). Banks, although with significantly larger assets, exhibited reduced levels of autonomy (9–12%), which coincided with the literature's warning about the risks of excessive financial exposure in highly competitive environments (Hermes & Nhung, 2010). In contrast, cooperatives exhibited more robust capital structures, supporting the hypothesis that resilience can be grounded in organizational models with greater autonomy and lower fragility (Pîslaru et al., 2023).

From a stakeholder theory perspective, the results suggested that cooperatives strengthened their position through more balanced capital structures and governance practices closer to their members, aligning with the contributions of Alqudah et al. (2025) on the importance of accountability for stability. In the case of banks, Cluster 2 (Banco de Bogotá) achieved a remarkable ROE (14.47%), but with low temporal persistence ($R^2 \approx 0.0001$), reflecting vulnerability to cyclical shocks and supporting the theoretical tension between efficiency and fragility (Alhassan & Ohene-Asare, 2016). This finding reinforced the relevance of adaptive regulatory strategies in emerging markets, such as those proposed by Hermes & Nhung (2010).

The literature based on resources and intellectual capital found partial support in this study. Although cooperatives achieved higher ROA values (2.45% in Coomultrasan and 2.05% in Crediservir), suggesting

relative efficiency in asset utilization, their ROE levels were lower than those of banks. This contrast validated the idea that competitiveness is not solely explained by size, but rather by the capacity to articulate internal structures with temporal resilience (Onumah & Duho, 2020; Abebe Zelalem & Abebe, 2022). The results also showed that the efficiency derived from capitalization and autonomy translated into stability, in line with the findings of Buenaño et al. (2025).

Furthermore, the clustering methods applied made a novel contribution compared with the predominance of traditional approaches in the literature (Cangombe et al., 2025). The combined use of benchmarking and cluster analysis enabled the identification of dominant financial profiles and the validation of their internal consistency, demonstrating that the clusters captured differences not only in scale but also in resilience. In this sense, the methodology aligned with recent recommendations on diversifying techniques (Jiménez-Hernández & Palazzo, 2019; Karsak & Goker, 2020) and broadened the understanding of the Colombian hybrid financial system.

Finally, the results highlighted persistent gaps in the international literature. Although previous studies have extensively analyzed banks under frameworks of efficiency, resilience, and innovation (Hermes & Nhung, 2010; Mirza et al., 2025), comparative analyses with cooperatives have been scarce. This study helped fill that gap by showing that, in the Colombian context (2016–2024), cooperatives exhibited comparative advantages in autonomy and resilience, while banks maintained their leadership in scale and profitability. A comparison with the current state of research suggests that financial competitiveness and resilience are not mutually exclusive dimensions, but rather interdependent, modulated by governance, capital structure, and adaptation to the regulatory environment.

CONCLUSIONS

The study revealed that financial competitiveness and resilience in the Colombian system are not explained by a single factor but by the interaction among scale, capital structure, efficiency, and temporal persistence. Banks benefited from the size of their assets and made a greater contribution to the sector's average ROE, but their high leverage and profit volatility highlighted weaknesses in their ability to sustain results in uncertain environments.

Although operating on significantly smaller scales, cooperatives projected relative strength in autonomy and asset efficiency, aspects that gave them comparative advantages over larger institutions. However, their profitability was vulnerable to external shocks and dependent on volatile trends, demonstrating that strong capitalization does not guarantee stable returns.

Intersectoral benchmarking validated that competitiveness and resilience should be understood as complementary dimensions: while the former is expressed in the capacity to generate returns and maintain market positions, the latter is linked to the persistence of these trends and the availability of capital buffers to absorb stress. In this sense, the identified areas for improvement highlight the need to balance leverage, autonomy, and consistent profitability across both the banking and cooperative sectors.

Finally, the findings suggest that financial and risk management policy should be geared towards a hybrid model that combines the economies of scale of banking with the more prudent structures of the cooperative sector. This learning provides practical guidance for formulating institutional and regulatory strategies to move towards a more competitive and resilient financial system in the long term.

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