Revista Científica PROFUNDIDAD Construyendo Futuro

ISSN PRINT: 2422-1783 / ISSN ONLINE: 2422-2518
Vol. 20 No. 20 /Enero-Junio 2024/p. 95-103 Ocaña, Colombia
DOI: https://doi.org/10.22463/24221783.4391

Eficiencia de Bancos y Cajas Municipales en el Perú, una Aplicación del Análisis Envolvente de Datos, para el Periodo 2003 - 2022.

Efficiency of Banks and Municipal Savings Banks in Peru, an Application of Data Envelopment Analysis, for the Period 2003 - 2022.

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Cite this article as: Ureña – López, F. F. (2024). Eficiencia de bancos y cajas municipales en el Perú, una aplicación del análisis envolvente de datos, para el periodo 2003 - 2022. Revista Científica Profundidad Construyendo Futuro, 20(20), 95–103. https://doi.org/10.22463/24221783.4391

Received: July 31, 2023 / **Approved:** December 22, 2022

Resumen

Se realizó un estudio longitudinal para evaluar la eficiencia de los Bancos y Cajas Municipales de Ahorro y Crédito (en adelante CMAC´s) en el ámbito de créditos a microempresas en el periodo 2003 a 2022, empleando el Análisis Envolvente de Datos (en adelante "DEA"). La muestra la conformaron 19 entidades financieras del sistema financiero peruano (en adelante "SFP") que operaron en el intervalo de análisis. Para la aplicación del DEA se consideraron variables de entrada (también denominadas "inputs"), que imitan la Función de Producción de Coub Douglas, a saber, cantidad de oficinas y número de personal de cada institución. Como resultado, se encontró que los Bancos son más eficientes que las CMAC´s incrementando su eficiencia en años recientes mientras que las CMAC´s presentaron una eficiencia similar con una constante tendencia decreciente. Por último, se realizó un modelo de Regresión Lineal a fin de determinar los factores asociados a la eficiencia Operativa, encontrándose a un 5% de significancia, que el logaritmo de las eficiencias calculadas es influenciado por la rentabilidad de patrimonio, el ratio de intermediación (crédito por depósitos), el tipo de entidad y el año de estudio.

Palabras claves: Eficiencia, bancos, cajas municipales, análisis envolvente de datos.

Abstract

A longitudinal study was carried out to evaluate the efficiency of Municipal Savings Banks and Savings Banks in the field of loans to microenterprises in the period 2003 to 2022, using the Data Envelopment Analysis (DEA). The sample was made up of 19 financial entities that operated in the analysis interval. For the Data Envelopment Analysis, input variables are considered, which imitate the Coub Douglas Production Function, namely, number of offices and number of personnel of each institution. As a result, it was found that the Banks are more efficient than the Municipal Savings Banks, increasing their efficiency in recent years, while the Municipal Savings Banks showed a similar efficiency with a constant downward trend. Finally, a Multiple Linear Regression Model was estimated to determine the factors associated with Operating efficiency, finding a 5% significance, that the logarithm of the calculated efficiencies is influenced by the return on equity, intermediation ratio (credit per deposit), type of entity and year of study.

Key words: Efficiency, banks, municipal banks, data envelopment analysis.

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1. Introduction

This article addresses the quantification of operational efficiency metrics for banks and Municipal Savings and Credit Institutions (CMACs), which collectively represent 93.30% of total loans and 66.70% of total borrowers within the country's Financial System (hereinafter referred to as the "SFP"). The research aimed to assess the performance of the main entities within the SFP using a non-parametric method known as DEA (Data Envelopment Analysis). Therefore, the following working hypotheses are proposed:

- The DEA methodology is applicable to the Peruvian context, as it effectively explains the efficiency levels at which both banks and CMACs manage their key resources.

- The number of branches and the workforce employed serve as inputs to evaluate the efficiency with which the financial institutions in question generate savings and loans.
- The intermediation coefficient (Loans/Savings) exhibits a positive relationship with the efficiency levels of banks and CMACs.
- Profitability ratios, such as Return on Equity (ROE) and Return on Assets (ROA), demonstrate a direct relationship with the operational efficiency of the banking and CMAC subsystems.

The efficiency rankings were determined based on the number of branches and personnel recruited by each financial institution over the last 20 years. The outputs, on the other hand, were established as the total loans granted and public deposits (savings) during the same period. Additionally, a regression model was analyzed to explain efficiency levels based on the financial intermediation ratio (loans to savings), return on equity (ROE), return on assets (ROA), the year under review, and the type of institution analyzed.

Table 1. *Peruvian Financial System Entities*

Entity	#	Loan Portfolio (%)
Banks	17	88.9%
Financial Institutions	9	2.9%
Municipal Savings Banks	12	7.0%
Rural Savings Banks	6	0.5%
Credit Companies	7	0.7%
TOTAL	**51**	**100.0%**

2. Theoretical Framework

Farrell (1957) defines technical efficiency by utilizing linear programming models to determine operational efficiency as the output achieved from a given set of inputs. Building upon this foundational work, numerous studies have employed the DEA (Data Envelopment Analysis) methodology to evaluate the performance of various companies. Berger and Humphrey (1997) conducted a comprehensive study on efficiency within the banking industry, summarizing findings from 130 efficiency studies on financial institutions across 21 countries, employing five distinct estimation approaches. Non-parametric studies, such as those utilizing DEA, are comparable to parametric approaches. However, non-parametric methods generally yield slightly lower average efficiency scores.

However, Berrío and Muñoz (2005), through a study on the efficiency of Colombian banks during the period 1993–2003, concluded the

following: i) The DEA methodology effectively distinguishes between efficient and inefficient firms by analyzing the inputs and outputs of specific decision-making units ("DMUs"). ii) Incorporating additional inputs and outputs into the study does not produce significant differences in efficiency indices among the analyzed units. iii) The study highlights the fragility of Colombian financial institutions, which shift from absolute efficiency to inefficiency. Efficiency levels above 90% were observed in only two banks.

In their preliminary work, Charnes et al. (1978) formulated a programming problem to measure efficiency through the allocation of x^j,\ y^j, , utilizing data from "n" observations within a sample, denoted as S_n{(x^k,\ y^k{)}}_{k=1}^n , for comparable DMUs that can be considered relevant pairs. This formulation aims to maximize an objective:

$$\frac{\sum_{m=1}^{M} u_m y_m^k}{\sum_{l=1}^{N} v_l x_l^j} \leq 1, k = 1, \dots, n, \qquad (1)$$

$$u_m \geq 0, m = 1, \dots, M,$$

$$v_l \geq 0, l = 1, \dots, M,$$

According to Arias (2009), who evaluated the efficiency of banks in Venezuela using the Deterministic Frontier technique during the period 2005–2008, the study revealed the following findings: i) From a managerial perspective, DEA provides greater robustness in assessing the performance of banking institutions, as it assigns a specific value to the effort required to position entities on the efficiency frontier., ii) under the variable returns to scale approach (DEA-VRS), the efficiency and cost performance of Venezuela's commercial banking sector were 94.67% and 85.82%, respectively. Furthermore, the study identified an average technical inefficiency index of 5.33% and a cost inefficiency index of 14.18%.

Fiorentino, Karman, and Koetter (2006) investigated the consistency of profitability measures derived from two different methodologies: Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). Using an identical dataset of universal banks in Germany spanning 1993 to 2004, their analysis based on five consistency criteria led to the following key conclusions: i) Average cost efficiency levels are significantly higher when measured using SFA compared to DEA. Two primary reasons were identified for these observations, ii) An analysis of efficiency rankings across methodologies and samples reveals limited evidence that both methods rank banks similarly. Only for the most restricted samples, segmented by group and year, do the two measures exhibit rank-order correlations of approximately 44%.

In the study by Gutiérrez (2007), the scores obtained under various model options and specifications are explained, providing efficiency measurements for each combination of inputs and outputs across 30 entities in Latin America. The findings reveal that the level of efficiency achieved by a Microfinance Institution is dependent on specific model specifications. Therefore, the selection of a particular model is crucial in determining efficiency.

3. Methodology

For this research, 19 financial entities were analyzed (comprising 7 banks and 12 CMACs) that had been around between 2003 and 2022. Entities that exited the market during the measurement period were excluded in order to ensure complete information and generate consistent results. The seven banks analyzed are:

Banco de Crédito del Perú, BBVA Continental, Interbank, Mi Banco, Banco Interamericano, and Citibank. Whereas the twelve CMACs studied include: Arequipa, Cusco, Trujillo, Maynas, Piura, Sullana, Huancayo, Tacna, Lima, Ica, Paita, and Santa. Yet, it is also important to note that accumulated information at the close of each fiscal year over the past 20 years was used, which was collected from the SBS, the regulatory body responsible for overseeing the Financial System of the Country (SFP). The study's inputs included the number of employees and the number of branches, while the outputs analyzed were the loans granted and public deposits.

DEA with continuous returns to scale was employed to ascertain the efficiency outcomes based on the specified inputs. Efficiency computations were performed utilizing the DEAR package, executed within the R Studio software environment. DEA is a non-parametric approach that evaluates technical efficiency by comparing inputs that generate outputs, assessing performance under analogous situations for the entities being analyzed. This analysis provides better tools for decision-making regarding resource allocation and outcomes. Consequently, in the Financial System of the Country (SFP), it is highly valuable as it generates multiple conclusions from various inputs, as noted by Johnes (2006).

The Decision-Making Unit (hereinafter referred to as "DMU") represents production based on the utilization of resources, having control over the transformation of inputs. This concept is well-articulated by authors such as Duguleană & Duguleană (2015).

The utilization of DEA was suggested for this research as a result of its capacity to establish a correlation between the inputs of the entities under analysis and the weighted outputs. This model evaluates the efficacy of a group of financial entities (Banks and CMACs) by identifying potential inefficiencies.

Efficiency measurement is conducted as follows. As per Farrell (1957), some conditions are required: i) convexity, and ii) absence of a positive slope at any point, ensuring that an increase in production factors does not reduce the output quantity. The graphic below illustrates the variables labor (L) and capital (K), utilized to generate outputs (results). In line with the stated conditions (convexity and positive slope) and as shown in the graph, the efficient isoquant is graphically represented by the curve Yo.

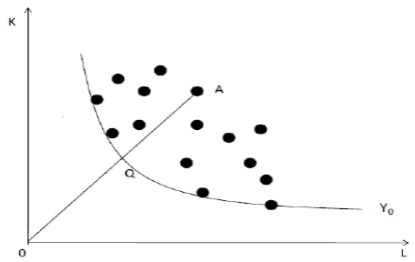

Figure 1. Efficient Isoquant. Source: Technical Efficiency and Neural Networks – Daniel Santín.

When conducting DEA analysis, two processes are applied simultaneously:

- The efficient frontier must be oriented toward the maximization or minimization of outputs given a specific level of resources utilized.
- To estimate inefficiency, each DMU or entity must be compared with another that possesses similar technological characteristics.

4. Outcomes

Then, the DEA methodology is applied, and the efficiency estimates under constant returns to scale are presented, along with

recommendations for banks and savings institutions to enhance their operational efficiency.

Table 2. *Efficiency Results for Banks and Municipal Savings and Credit Institutions – Peru 2013–*

DMU	PROM	DMU	PROM
Citibank	1.00	Maynas	0.15
B. BBVA	1.00	Piura	0.15
Interameric.	0.77	Sullana	0.15
BCP	0.75	Huancayo	0.14
Interbank	0.55	Tacna	0.14
Comercio	0.34	Lima	0.13
Arequipa	0.19	Ica	0.13
Mibanco	0.18	Paita	0.09
Cusco	0.17	Santa	0.09
Trujillo	0.16		

4.1 Pre- and post-COVID-19 Analysis

The following figure compares the distribution of efficiency calculated before and after COVID-19, based on the type of entity, using the central 50% of the data. It shows a higher median efficiency value for banks (around 75%) compared to CMACs, with banks displaying greater dispersion. In contrast, CMACs show a median efficiency value around 13%, with lower dispersion than the banks. For both types of entities, there has been a decrease in calculated efficiency over the last three years, with CMACs exhibiting the most significant drop.

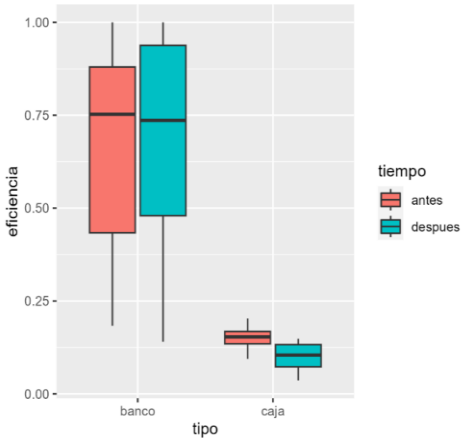

Figure 2. Box plot before and after COVID-19. Source: Self-made.

In the case of banks, both before and after COVID-19, the dispersion remains the same, with a tendency toward higher efficiency. In contrast, CMACs exhibit low and similar dispersion, along with a decline in efficiency following the COVID-19 pandemic.

4.2 Consistency of Results

After estimating the operational efficiency of CMACs and banks, a Multiple Linear Regression was conducted to determine which economic factors affect their efficiency. The economic characteristics included in the model were deposits (in Peruvian Sol), credit (in Peruvian Sol), equity (in Peruvian Sol), Return on Equity (ROE), Return on Assets (ROA), the year of analysis (ranging from 2003 to 2022), and the type of entity (Bank or Municipal Savings and Credit Institution).

In the figure below, the distribution of efficiency across financial entities is displayed. On the left side, it is observed that the calculated efficiencies are primarily concentrated around low values (corresponding to the CMACs), as well as at the unit efficiency level (corresponding to the Banks). Since the data is required to fit the well-known Gaussian curve (bell curve, for the assumption of probabilistic

normality), the natural logarithm operator was applied, and efficiencies below 1 were considered.

The outcome of this becomes evident on the right side of the figure, where a clearer symmetry can be observed.

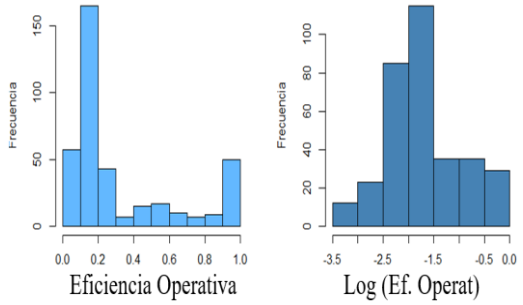

Figure 3. Efficiency Distribution.
Source: self-made.

According to the figure, there is a linear association between the logarithm of efficiency and the predictors. At the bank level, an association is found between the logarithm of efficiency and the level of deposits, Return on Assets (ROA), and Return on Equity (ROE). At the CMAC level, an association is found between the logarithm of efficiency and ROA, ROE, and the year of analysis.

On the other hand, potential collinearity issues were identified among the predictors, particularly between credit and deposits, which exhibit a 99.6% correlation. This is expected, as the primary funding source for the financial entities under analysis consists of public deposits in the form of savings. To address these collinearity issues between deposits (in Peruvian Sol) and credit (in Peruvian Sol), the proportion of credit disbursed to total deposits was calculated, which serves as a metric to quantify the entities' capacity to allocate credit from the total funds invested. In practice, this calculation is commonly referred to as the financial intermediation margin.

Ultimately, at a 5% significance level, the following variables are found to significantly influence the logarithm of efficiency: i) Return on Equity (ROE), ii) the financial intermediation ratio, measured as the ratio of credit to deposits, iii) the type of entity, and iv) the year. An adjusted R^2 value is obtained, explaining 78.2% of the variability in the logarithm of operational efficiency.

The following section provides an interpretation of the effects of these variables. Since the efficiency variable was included in its logarithmic form, the impact of a one-unit increase in the predictors affects efficiency in percentage terms:

- Return on Equity (ROE): An increase of one unit in the value of ROE leads to an average increase in efficiency of 158.8%, assuming all other predictors remain constant.

- Financial Intermediation Ratio**:** An increase of one unit in the financial intermediation margin results in an average efficiency increase of 14.9%, assuming all other predictors remain constant.

- Type of Entity: The reference entity is banks. CMACs display, on average, 131.3% lower efficiency compared to banks, assuming all other predictors remain constant.

- Year of Study**:** Each additional year of operation for the entities results in an average efficiency decrease of 1.9%, assuming all other predictors remain constant.

Table 3. *Linear Regression Model*

Variable	Coef	SE[1]	95% CI[1]	P - value
ROE	1.588	0.201	1.192, 1.984	0

Revista Científica Profundidad Construyendo Futuro. 20 (20), Enero-Junio, 2024, p.95-103 ISSN Print: 2422-1783 ISSN Online: 2422-2518

Ratio	0.149	0.059	0.032, 0.265	0.012
Equity	0	0	0.000, 0.000	0.006
Type				
CMAC	-1.313	0.051	-1.414, -1.212	0.00
Year	-0.019	0.005	-0.029, -0.010	0.00
R^2	0.785			
Adjusted R^2	0.782			

1SE = Standard Error, CI = Confidence Interval

The Constant Variance Test is utilized to validate the premise of homoscedasticity, whereas the Shapiro-Wilk Test is employed to assess normalcy. Under the null hypothesis, it is posited that the assumption is satisfied, whereas under the alternative hypothesis, it is posited that the assumption is contravened. Table 2 demonstrates that the statistical tests for homoscedasticity and normality of residuals produce non-significant findings (p-value > 0.05), confirming that these assumptions are met.

Table 4. *Statistical Tests to Verify Regression Assumptions*

Test	Test Statistic	P value
Constant Variance of Scores	0.0571	0.8111
Shapiro Wilks	0.992	0.0685

5. Discussion

Regarding the efficiency levels of the 19 financial institutions, Jiménez (2020) argues that it cannot be asserted that high levels of concentration, and thus more competition, necessarily make them more efficient. For this research, the conditions to test this hypothesis are not present. The first issue is that loans and deposits are highly correlated, and the second is that estimating a regression model requires that the measurements of the study units be independent. Yet, indirectly, within the Peruvian context, there is some influence of credit concentration metrics on the efficiency levels achieved, which is masked through the financial intermediation margin. Therefore, at this point, no conclusive results have been found.

The hypothesis that concentration increases competition and, therefore, efficiency does not allow for clear inferences (Jiménez, 2020). While the studies analyzed explain that retail financing in concentrated markets shows higher levels of competition, this result contrasts with wholesale and mortgage placements, which also exhibit concentration. On the contrary, the study argues that consumer financing with lower concentration is more efficient than other portfolios.

As per the data presented by the Central Bank of Nicaragua (2010), it is concluded that the financial intermediation spread is a significant measure of the efficiency of financial institutions. The implementation of homogeneity in accounting practices enhances comparative analysis.

Regarding the CMACs, Sanchis (2009) demonstrates in his work that, despite performing a significant social function within the scope of the social economy, the Savings and Credit Institutions achieve high levels of profitability and efficiency, similar to those of other financial entities that do not belong to the social economy, which makes them viable and solid.

6. Conclusions

Based on the research conducted, it is concluded that

- Banks show higher efficiency levels than the CMACs. In the banking segment, the most efficient entity (Citibank) directs its placements towards the corporate and large business segments, hiring a smaller group of employees and operating with a single office nationwide.

  The four largest banks in the country in terms of equity level do not necessarily show the highest efficiency.

- The CMACs are positioned lower than the banks in terms of efficiency generation, which is due to a greater reliance on labor resources. This is because their employees must place loans in different geographical areas, primarily targeting micro and small businesses, thereby increasing personnel expenses concerning traditional banking.

- Caja Arequipa, which maintains one of the highest levels of assets and market share in its segment in terms of loans (23.12% of the CMAC subsystem) and deposits (21.41% of the CMAC subsystem), holds the leadership in efficiency generation within the CMAC segment during the analysis period.

- At a 5% significance level, the variables of Return on Equity (ROE), the financial intermediation ratio measured as the ratio between loans and deposits, the type of entity, and the year significantly influence the logarithm of the achieved efficiency. As a whole, they yield an adjusted R^2 value that explains 78.2% of the variability in the logarithm of the determined efficiency. It is important to note that the degree of credit concentration indirectly influences efficiency through the intermediation margin.

- Post-COVID-19 pandemic, variations in efficiency have been observed. In the case of banks, the dispersion before and after COVID-19 remains similar; however, for the CMACs, there is a decrease in efficiency post-COVID. This finding could be related to better management in terms of innovation and the use of ICTs in banking compared to the CMACs. It is worth noting that the CMACs have focused on commercial strengthening through the creation of more service centers (branches) across the country, while banks have concentrated on the use of information technology.

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