Contaduría y administración
ISSN: 0186-1042
ISSN: 2448-8410
Facultad de Contaduría y Administración, UNAM

Campoverde Campoverde, Jorge Arturo; Romero Galarza, Carlos Armando; Borenstein, Denis

Evaluación de eficiencia de cooperativas de ahorro y crédito en Ecuador: aplicación del modelo Análisis Envolvente de Datos DEA

Contaduría y administración, vol. 64, no. 1, 2019, January-March, pp. 1-19
Facultad de Contaduría y Administración, UNAM

DOI: https://doi.org/10.22201/fca.24488410e.2018.1449

Available in: https://www.redalyc.org/articulo.oa?id=39571679011

www.cya.unam.mx/index.php/cya

Contaduría y Administración 64 (1), 2019, 1-17

Contaduría y Administración
Accounting & Management

Evaluation of the efficiency of savings and credit cooperatives in Ecuador: A Data Envelopment Analysis (DEA) Aplication

Evaluación de eficiencia de cooperativas de ahorro y crédito en Ecuador: aplicación del modelo Análisis Envolvente de Datos DEA

Jorge Arturo Campoverde Campoverde[1], Carlos Armando Romero Galarza[1*], Denis Borenstein[2]

[1] *Universidad de Cuenca, Ecuador*
[2]*Universidade Federal do Rio Grande do Sul, Brasil*

Received 22 March 2017; accepted 20 February 2018
Available online 25 November 2018

Abstract

One of the foremost pillars of the Ecuadorian financial system is the one made up by Savings and Credit Cooperatives, due to its high growth in recent years and the large number of customers that has been able to attract. The main purpose of this study is to make an analysis about the technical effectiveness of 18 Savings and Credit Cooperatives (COACs) considered in "Segment 1" in the ranking of Ecuadorian cooperatives in 2016, presented by the Superintendency of Popular and Solidarity Economy (SPSE). The dataset used for the analysis corresponds to a ten-year period, 2007-2016. We have used the DEA model (Data Envelopment Analysis) to measure the level of efficiency for each cooperative, obtaining as a result an average of 77.02% of efficiency in all analyzed period, giving as a result only one cooperative with the hundred percent of efficiency.

JEL Codes: C14; C61; D57
Keywords: Data envelopment analysis; Efficiency; Savings and credit cooperatives; Decision making unit

*Corresponding author.
E-mail address: armando.romerog@ucuenca.edu.ec (C. A. Romero Galarza).
Peer Review under the responsibility of Universidad Nacional Autónoma de México.

http://dx.doi.org/10.22201/fca.24488410e.2018.1449

Resumen

Uno de los pilares importantes del Sistema Financiero Ecuatoriano es el constituido por las Cooperativas de Ahorro y Crédito, debido a su amplio crecimiento obtenido en los últimos años y la gran cantidad de clientes que han logrado atraer. El objetivo principal de este estudio, es realizar un análisis sobre la Eficiencia Técnica de 18 Cooperativas de Ahorro y Crédito (COACs) consideradas en el "Segmento 1" del ranking de cooperativas ecuatorianas presentadas por la Superintendencia de Economía Popular y Solidaria (SEPS) en el periodo 2016; para el análisis utilizaremos un conjunto de datos financieros de cada cooperativa, correspondientes a un periodo de 10 años, 2007-2016. En este contexto hemos utilizado el modelo DEA (Data Envelopment Analysis) para determinar los ratios de eficiencia de cada cooperativa, obteniendo como resultado un promedio de 77.02 % de eficiencia en todo el período analizado, y resultando una sola cooperativa con el 100% de eficiencia.

Códigos JEL: C14; C61; D57
Palabras clave: Análisis envolvente de datos; Eficiencia; Cooperativas de ahorro y crédito; Unidades de toma de decisiones.

Introduction

At the global level, the first social economic organizations were born following the Industrial Revolution in England between 1750 and 1840, as a response to the impoverishment caused in the less favored social classes. In the middle of the 19th century, the first credit unions emerged, which were characterized by having an alternative approach to the market economy and thus curbing the exploitation and impoverishment felt in society. In Ecuador, the first unions were born in the guilds of craftsmen, workers, merchants, employees, and employers, linked to the socialist and liberal parties as well as to the Catholic Church. *The Sociedad Protectora del Obrero* (Workers Protection Association)—considered the first Ecuadorian union—was founded in Guayaquil in 1919 (Miño, 2013).

Within the history of unions in Ecuador and referring to the most significant events that have arisen, we can cite that in the late 1980s and early 1990s this financial sector had a decline in its growth due to the closure of some small and medium unions (Miño, 2013). This same author announces that by the end of the 1990s—when the country presented one of the biggest financial crises in its history, the main event of which was the bank holiday of 1999 that brought with it the fall and closure of approximately 20 banking institutions—the general public lost confidence in the banking sector and, therefore, turned this confidence to the credit union sector, which experienced significant growth. In this situation, unions are forced to implement greater security measures and control over their assets for the tranquility of their clients and administrators. By 1999, according to data from the Federation of Savings and Credit Cooperatives (FECOAC for its acronym in Spanish), the confidence and solvency of the citizens was reflected in the increase in deposits, especially fixed-term deposits, which grew by 116% from January to June.

By 2016, Ecuador had a total of 921 credit unions registered in the 5 segments of the Financial Cooperative Sector registry[1] of the SEPS. Until 2015 Ecuador was the second country

[1] Cadastre of segmentation of Financial Cooperatives, taken from: https://servicios.seps.gob.ec/gosf-internet/paginas/consultarOrganizaciones.jsf

in Latin America after Brazil to have the largest number of credit unions; the credit union sector has had a great impact on economic development since approximately 66% of microcredits granted correspond to this system, thus differentiating it from the banking system.[3]

In the production environment of the different industrial sectors it is common to find efficiency studies based on the initial work by Farrel (1957), same which have served as a theoretical framework for the creation of several concepts on efficiency. In this context, Technical Efficiency (TE) is considered for each Decision-Making Unit (DMU) as the maximization of the results obtained from the resources that were used. Thus, efficiency can be approached from two different directions: the first is oriented towards input variables where inputs are minimized, while DMUs remain in the frontier of production possibilities; and the second is oriented towards the maximization of the output variables given a fixed level of input variables (Navarro & Torres, 2006). However, any of the approaches of the DEA analysis allows defining an efficient frontier with the leaders of the sector (Belmonte & Plaza, 2008). In turn, Valencia & Chediak (2008) indicate that efficiency is based on the resulting coefficient between the products and inputs of the DMUs, with these being: companies, schools, hospitals, municipalities, or any organization that produces goods or provides a service.

Coelli *et al.*, as cited in Restrepo & Villegas (2011) and Benavides & García (2014), state that there are several methods that have been used to measure the efficiency of organizations, such as: econometric techniques, price indices and, presently, Data Envelopment Analysis. There are several studies on efficiency analysis in unions, exhibiting unanimity in the use of the DEA methodology to measure the efficiency of the union sector in different countries during certain periods of time and combinations of different analysis models derived from this methodology. This is evidenced by (Andrieş & Cocriş, 2010; Asawaruangpipop & Suwunnamek, 2014; Belmonte & Plaza, 2008; Joseph & Pastory, 2013; Lemos, Seido, & Monforte, 2007; Marrero Ancízar & Ortíz Torres, 2016; Santana Ramírea, 2015).

Asawaruangpipop & Suwunnamek (2014) used DEA to research the pure, technical, and scale efficiencies of 732 Credit Unions in Thailand. For this, they classified unions according to the segment to which they belong: professors, police, military, etc. Efficiency was assessed using the Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) models, while also presenting the average values by type of union. As a result, it was observed that under the CRS and VRS model, unions that belong to the public sector obtained the highest efficiency averages, with 90.04% and 93.43%, respectively.

Xueping, Jie, & Hongxin (2011) analyzed the efficiency of rural Credit Unions in the province of Hubei in China. This study comprised the analysis of the system of credits granted to rural houses. Fifty-four unions in total in a period of three years. To this end, they applied the CRS and VRS methods. The results showed that the evaluation carried out with the VRS model obtained greater ranges of efficiency.

Joseph & Pastory (2013) carried out a study concerning the Credit Unions in three regions of Tanzania, where they employed the DEA methodology to measure the efficiency of 37 rural credit unions. The result indicates that, in average, unions were shown to be inefficient in the 3 regions of analysis, thus determining that the main reason for said inefficiency are the high operational costs.

---

[2] SEPS news, taken from: http://www.seps.gob.ec/noticia?ecuador-tiene-un-total-de-887-cooperativas-de-ahorro-y-credito.

http://dx.doi.org/10.22201/fca.24488410e.2018.1449

Lemos *et al.* (2007) applied the DEA methodology to measure the efficiency of the rural credit unions of the state of Sao Paulo, Brazil. The study determined that credit unions with a high volume of resources have achieved greater efficiency indices, considering the proportion of the total assets and the administration spending with relation to the granted volume of credits. The analysis of different cases in which the DEA methodology has been applied has allowed us to obtain a clearer vision of the work done and to establish a different and complementary approach to the studies that have been done.

Moreno Sierra & Rey Huertas (2017) applied the DEA methodology to evaluate the efficiency of the credit unions in Colombia. Their analysis connected the efficiency of the credit union to the permanence and the success of the organizations. The study included two approaches: the financial approach that considers administrative expenses and social capital as inputs, and surplus as outputs; and a second approach aimed to determine the unions with the best practices where the number of associates and administrative expenses were considered as inputs, while the credit portfolio was considered an output. The final results determined that the efficiency of credit unions in Colombia is low.

The main objective of this work is to measure and analyze the relative efficiency of 18 credit unions classified within "Segment 1" in Ecuador, applying the DEA methodology. The analysis was done considering the closing financial statements of the period of 2007-2016 as base information, obtaining in this manner the annual efficiency of the same, which will make it possible for us to compare their institutional growth and their efficiency indicators.

Once the efficiency ratios of the credit unions were obtained, we were able to establish the following secondary objectives: (i) to monitor in time the capacity of each Credit Union (CU) to reach an optimal efficiency level; (ii) to offer information to the population that will help them define the best option when opening an account in a specific union; (iii) to clearly establish the input and output variables that must be adjusted (improved) so that unions can reach optimal efficiency levels.

The content of this article is organized in four sections: the first one refers to the description of the revised literature and the mathematical model to be used; section two indicates the methodology used for the collection and analysis of data; section three contains the results obtained, as well as a financial analysis; finally, we present the conclusions derived from the research. We will use different tables and graphs that show, with more clarity, the results obtained.

Data Envelopment Analysis (DEA)

The DEA method is an efficiency measurement technique based on the creation of a virtual frontier of optimal production that results from the best combination of input and output variables. The efficiency of each DMU is measured in ratios obtained from the presentation of linear programming problems where it is necessary to maximize or minimize the function according to the orientation of the analyzed variables (inputs, outputs). Once the frontier has been built, the efficiency of each unit observed is evaluated. A DMU below this production frontier is considered inefficient and its level of inefficiency is measured with the difference between one and the ratio obtained in its product-input ratio and vice versa. The DMUs considered efficient will be those located at the frontier and whose efficiency ratio is equal to 1, thus being considered 100% efficient. The data analysis also establishes a categorization to each of the DMUs according to the efficiency level obtained.

The DEA method was developed by Charnes, Cooper, & Rhodes (1978) and utilizes the assumption of constant returns to scale (CRS) or CCR (by the names of its authors), where initially it was used to measure the efficiency of production of a single analysis considering input and output variables. This version was improved by Banker, Charnes, & Cooper (1984), who included variable returns to scale (VRS) or BCC (by the names of its authors), thus modifying the original model of linear programming.

CCR and BCC models

The CCR model generates (n) optimizations of numbers to measure the efficiency in each DMU_j for (j=1,2,3….n). The optimization problem is presented considering input variables such as V_i for i=1,2,3….m, and output variables such as Ur for r=1,2,3….s. Thus we obtain:

Objective function:

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1$$

$$u_r, v_s \geq 0$$

For the measurement of efficiency, the objective function is transformed into a linear programming problem in which the numerator (output variable) is maximized, maintaining a constant denominator (input variables) (Cooper, Seifor, Tone. 2007).

Objective function:

$$\max h_o = \sum_{r=1}^{s} u_r y_{rj}$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{ij} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} \leq \sum_{i=1}^{m} v_i x_{ij}$$

$$u_r, v_s \geq 0$$

The BCC model is based on a modification of the basic CCR model, where Banker (1984) adds the concept of varying yields to scale, evaluating DMU_j (j=1,…,n), solving the following mathematical model presented for its objective function and primal restrictions.

http://dx.doi.org/10.22201/fca.24488410e.2018.1449

Objective function:

$$\min h_o$$

Subject to:

$$\sum_{j=1}^{n} y_{rj}\lambda_j - S^o = y_{ro}$$

$$h_o x_{io} - \sum_{j=1}^{n} x_{ij}\lambda_j - S^i = 0 \ (for: j = 1 \ldots . n)$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$$S^i \geq 0$$

$$S^o \geq 0$$

Where λ is a non-negative variable that determines the weightings of the group of reference companies with respect to the evaluated company DMU_j, and variables S^o and S^i are primal clearance variables

Comparison and selection of the model

In the development of the models it can be observed that the two present similarities due to their orientation to measure efficiency ratios, with the existing relation between input and output variables. The only difference that the BCC model presents is the introduction of convexity restrictions. Coll & Blasco (2006) note that the convexity restriction ensures that the combined unit is of a similar size to the other units and it is not an extrapolation of another combined unit that operates at a different size scale. Boussofiane, Dyson & Thanassoulis (1991) and Pedraja & Salinas (1996) indicate that the BCC model was presented with the objective of estimating the purely technical efficiency, eliminating the influence that the existence of scale economies could have on the evaluation of the efficiency ratio of the DMUs. Furthermore, the CCR model has the proportionality between inputs and outputs in the frontier as a main characteristic. This means that the increase (decrease) in the quantity of inputs will cause growth (reduction) that is proportional to the value of the outputs. In the BCC model, the DMU with the lowest value of a certain input or output will be efficient. This DMU is considered efficient by default or at the start (Charnes, Cooper, Lewin, & Seiford, 1994).

From the above we can say that the BCC model is adequate when working with DMUs that have similar sizes and that work with scale economies. In our case study, the DMUs do not have similar sizes. As can be observed in Table 1, there is a great size difference between the DMUs; for example, between CU 1 and CU 18, therefore, the CCR model is the most adequate in this analysis. Moreover, the credit unions do not work with scale economies. Finally, the study aims to determine those completely efficient DMUs with respect to the relationship between the variables, which would certify the usefulness of the model.

http://dx.doi.org/10.22201/fca.24488410e.2018.1449

Methodology and data presentation

Methodological procedure

The development of the research is done in three stages exposed below.

First stage: The DEA model to be used to obtain the efficiency indices is defined, choosing the CCR model which is oriented towards input variables (CCR-I). This orientation will allow obtaining the yield of each DMU through the maximum reduction of its input levels. The CCR model allows establishing which companies, in this case credit unions, determine the enveloping surface or the efficient production frontier, thus defining a greater efficiency area. Additionally, data was collected on the input and output variables, same which were taken from the bulletins[3] published in the website of the SEPS, where the annual financial information of each union is found.

Second stage: organization and structure of the information (input and output variables) in the format established for the reading of the software used. The data analysis will be done through the information tool: DEA-SOLVER-LV8 (2014-12-05), Microsoft Excel 2013, and IBM SPSS Statistics 20.

Third stage: presentation and analysis of the results obtained, presentation of relevant information during the analysis period.

Variable description

We did not find a consensus on the use of variables for the measurement of efficiency in the credit union system in previous researches in the Ecuadorian financial sector. For this reason, we will analyze different approaches used for the definition of inputs and products in the efficiency analysis of the credit union sector. Favero & Papi; L (1995) present different types of approaches, among which are: intermediation, production, assets, user cost, and added value. The first three developed according to the functions carried out by the financial institutions.

In this context, the better known and used approaches when determining efficiency are production and intermediation (Lindley & Sealey, 1977), where different views on the mission of the entities (unions) are presented.

Thus, for example, the production approach considers banks as deposit and loan producers, which use inputs such as capital and labor to produce deposits and loans. On the other hand, the intermediation approach indicates that banks are intermediaries that transfer financial resources from the surplus agents to those with a deficit, for this, the bank utilizes the following as inputs: deposits, other funds, equity, and work to transform them into products such as loans and financial investments. The applicability of each method varies according to the circumstances (Tortosa, 2002).

In an exhaustive search for the correct determination of the input and output variables used to measure efficiency, we were able to determine that the same is measured according to the ratios obtained from the application of financial indicators or the ranking according to the total capital (SEPS, EKOS journal, Management journal). There are several works that present a classification of financial entities that measure the performance in the Ecuadorian market where one of the methodologies used is the one called CAMEL[4]. This methodology measures and

[3] SEPS (*Superintendencia de Economía Popular y Solidaria*) in its website www.seps.gob.ec in the section of cooperative sector (Segment 1 Bulletin).

analyzes five essential parameters: capital, assets, corporate management, profit, and liquidity. As an example, we can cite the EKOS[5] business journal, which applies this method to create a classification of financial entities according to their performance.

From the financial point of view, Credit Unions base their function on the collection of savings, the granting of credits, and the offering of other financial services in common (SEPS, 2016), which are the reasons why in our case study we will utilize the intermediation approach. We have analyzed the most important variables in this activity, for which we previously reviewed studies done on the efficiency of credit unions in different places around the world and, based on this, we carried out a comparative analysis of the variables used in each case, even considering the relevance and importance of each one of them in the Ecuadorian context.

In this study we considered it feasible to utilize the following input and output variables for the measurement of efficiency in the credit union sector based on the intermediation approach.

Inputs

Operation Costs (OC): those costs incurred for the normal functioning of the operation portion of the company, same which has sub-accounts such as: personnel expenses, salaries, miscellaneous services, taxes, contributions and fines, depreciations, amortizations, and other expenses.

Uncollectable Fund (UF): the asset account formed by a portion of the money allotted to provisions for uncollectable credits, that is to say, for the money that cannot be recovered in its entirety but that must be maintained as a provision. This account is made up of different credit portfolios such as: consumer, housing, educational, structural, credit technology, productive, microcredits, real estate credit, commercial, as well as provisions: generic by credit technology, anti-cyclical, voluntary, and provisions not reversed by regulatory requirement.

Outputs

Total deposits (TD): the money given by a person to an entity so that said entity can protect it and respond to the person when they so request to maximize its interests. All deposits obtained and accepted by each of the CUs as savings deposits.

Accounts receivable (AR): those loans that were made at a specific time and are due from different types of credits given at an institution.

Available Funds (AF): those resources with more liquidity that serve to make current payments. Among the accounts, we have: cash, petty cash, banks, and other local or foreign financial institutions, the Central Bank of Ecuador, immediate collection effects, internal or external remittances.

Service Revenues (SR): those aspects obtained from the provision of different services such as: fiduciary services like collections, affiliations, and renovations due to financial advising and other services.

---

[4] CAMEL. Uniform rating system for financial institutions. It is based on a set of representative indicators of capital adequacy, solvency, asset quality, efficient asset management, the level and stability of profitability, as well as liquidity management. The method evaluates and summarizes financial, operational, and compliance factors. It has the advantage of summarizing in a single indicator the general situation of the financial institution, standardizing the analysis of the situation of individual institutions.

[5] EKOS journal, taken from its website: http://www.ekosnegocios.com/negocios/verArticuloContenido.aspx?idArt=5403

Data description

The input and output data of each of the CUs were obtained digitally from the annual bulletins published by the SEPS in its website, and they are corroborated in the websites of each of the CUs. The information bulletins of the SEPS collect the financial information (Balances, Result statements, among others) of the 18 CUs that must report on a monthly basis to this regulating body. The data taken correspond to the period of 2007-2016. It is worth noting that the data of each of the input and output variables are expressed in thousands of dollars.

For a better analysis, the most relevant data of the CUs are detailed, taking into consideration that the location of each is given by the area distribution of the different provinces of Ecuador and the place where the main matrix is located.

Table 1
Presentation and categorization by size of the 18 CUs

FULL NAME	*COMMERCIAL NAME*	*DMU ABBREVIATION*	MAIN LOCATION	TOTAL CAPITAL 2016 (Thousands of dollars)
Cooperativa de Ahorro y Crédito Juventud Ecuatoriana Progresista Ltda.	Juventud Ecuatoriana Progresista (JEP)	CU 1	Zonal 6 Cuenca	1,187,758.36
Cooperativa de Ahorro y Crédito Jardín Azuayo Ltda.	Jardín azuayo	CU 2	Zonal 6 Cuenca	639,156.94
Cooperativa de Ahorro y Crédito 29 de Octubre Ltda.	29 de Octubre	CU 3	Zonal 2 Quito	354,485.21
Cooperativa de Ahorro y Crédito San Francisco Ltda.	San Francisco	CU 4	Zonal 3 Ambato	295,886.82
Cooperativa de Ahorro y Crédito Oscus LTDA	Oscus	CU 5	Zonal 3 Ambato	286,800.11
Cooperativa de Ahorro y Crédito Riobamba Ltda.	Riobamba	CU 6	Zonal 3 Ambato	264,582.46
Cooperativa de Ahorro y Crédito Vicentina Manuel Esteban Godoy Ortega Ltda.	MEGO	CU 7	Zonal 6 Cuenca	247,177.99
Cooperativa de Ahorro y Crédito De la Pequeña Empresa de Cotopaxi Ltda.	CACPECO	CU 8	Zonal 3 Ambato	211,259.11
Cooperativa de Ahorro y Crédito Alianza del Valle Ltda.	Alianza del Valle	CU 9	Zonal 2 Quito	201,602.64
Cooperativa de Ahorro y Crédito Andalucía Ltda.	Andalucía	CU 10	Zonal 2 Quito	191,198.13
Cooperativa de Ahorro y crédito Atuntaqui Ltda.	Atuntaqui	CU 11	Zonal 2 Quito	152,237.84
Cooperativa de Ahorro y Crédito De la Pequeña Empresa Biblián Ltda.	CACPE Biblián	CU 12	Zonal 6 Cuenca	150,449.79
Cooperativa de Ahorro y Crédito El Sagrario Ltda.	El sagrario	CU 13	Zonal 3 Ambato	144,183.23
Cooperativa de Ahorro y Crédito 23 de julio Ltda.	23 de Julio	CU 14	Zonal 2 Quito	129,815.22
Cooperativa de Ahorro y Crédito Pablo Muñoz Vega Ltda.	Pablo Muñoz Vega	CU 15	Zonal 2 Quito	124,812.79
Cooperativa de Ahorro y Crédito Tulcán Ltda.	Tulcán Ltda.	CU 16	Zonal 2 Quito	124,384.79
Cooperativa de Ahorro y Crédito San José Ltda.	San José Ltda.	CU 17	Zonal 3 Ambato	121,429.56
Cooperativa de Ahorro y Crédito Santa Rosa Ltda.	Santa Rosa	CU 18	Zonal 5 Guayaquil	93,632.13

Source: SEPS 2016

http://dx.doi.org/10.22201/fca.24488410e.2018.1449

The table above samples, in a general manner, the data of each of the CUs to be analyzed and the terms to be used. The order in which the CUs are presented is by size, given the amount of their total capital until December of 2016.

Data validation

Before obtaining the efficiency ratios we have validated the set of data used for each variable, which was done through a Pearson's correlation analysis with the average values of each variable during the decade of the analysis. This allowed us to measure the existing relation between each of the input and output variables.

Table 2
Variable correlation analysis

	OC	UF	AF	AR	TD	SR
OC	1					
UF	0.787**	1				
AF	0.895**	0.839**	1			
AR	0.966**	0.835**	0.889**	1		
TD	0.966**	0.865**	**0.920****	**0.969****	1	
SR	0.754**	**0.415**	0.630**	0.752**	0.633**	1

**. The correlation is significant at a level of 0.01 (bilateral).
Source: Own elaboration with data from the SEPS (2007-2016)

It was possible to determine the level of existing relationship between each variable with the correlation analysis, observing that the most significant relationship is produced between the AR and TD variables due to the fact that, with a greater amount of deposits in a credit union, the greater the availability of the portfolio for the granting of credits. While the lowest level of correlation is between the UF and SR variables, which due to the level of significance do not seem to be significant. This could be due to the fact that profits from services do not represent a high percentage in the funds destined for credits. There is also a high level of correlation between the AF and TD variables, due to the fact that they maintain a close relationship in their objectives given that the AF account is a direct consequence of TD, that is, with a greater amount of deposits comes a greater level of available funds.

Regarding the results obtained in the correlation study, the need to have additional indicators that will help proper decision-making concerning the variables to be used in the model became present. For this reason, a linear regression analysis and a variance analysis were carried out. These were done using the average values of each of the variables in the analysis period. This analysis resulted in an amended correlation coefficient (R^2) equal to 0,978, and a beta value (β) in the IS variable of -61,699.

Based on these analyses, it was suggested to not use the AF and SR variables, with the variables below remaining:

Inputs

- Operation Costs OC
- Uncollectable Funds UF

Outputs

- Accounts Receivable AR
- Total deposits TD

Finally, the decision was made to use a DEA model with two input variables and two output variables. Given the new selection of variables, another linear regression analysis was carried out, obtaining the following results.

Table 3
Regression statistics

Model	R	R squared	Corrected R squared	Standard error of the estimation
1	0.983a	0.966	0.959	20304.47261

a. Predictive variables: (Constant), AR, UF, CO
Source: Own elaboration with data from the SEPS (2007-2016)

Table 4
Anova

	Sum of the squares	gl	Quadratic mean	F	Sig.
Total	166271749339.420	3	55423916446.473	134.435	0.000[b]
Residual	5771802511.855	14	412271607.990		
Regression	172043551851.275	17			

a. Dependent variable: TD; b. Predictive variables: (Constant), AR, UF, OC
Source: Own elaboration with data from the SEPS (2007-2016)

Table 5
Coefficient analysis

	Non-standardized coefficients		Typified coefficients	t	Sig.
	B	Typical error	Beta		
(Constant)	-24292.675	10817.805		-2.246	0.041**
OC	9.575	3.583	0.513	2.672	0.018**
UF	5.736	2.359	0.218	2.432	0.029**
AR	24.501	18.156	0.291	1.349	0.199

a. Dependent variable: TD
b. * p< 0.1 **p<0.05 ***p<0.01
Source: Own elaboration with data from the SEPS (2007-2016)

Table 5 presents the results of the regression, where it is possible to observe that the deposits (TD) correspond to 3 variables: Operation Costs (OC), Uncollectable Funds (UF), and Accounts Receivable (AR). Statistically, Operation Costs and Uncollectable Funds explain the total deposits. However, accounts receivable is not an explicative variable, but it is nevertheless necessary to include it in the model as it represents a spurious variable, that is, theoretically it must be considered to explain the model. On the other hand, the positive results of the standardized and typified coefficients represent the expected and proper values for the research. It can also be observed that there is an R^2 value that indicates a better adjustment when executing the model with the 4 variables. The high value of the coefficient is justified with the reduced number of variables used and the amount of data for each one.

http://dx.doi.org/10.22201/fca.24488410e.2018.1449

Results

The table represented below shows the efficiency result executed for the decision units in each one of the analyzed years. It should be noted that within each year, the efficiency of the different CUs has suffered variations that could be the reason behind different decisions and forms of management in each financial institution.

Table 6
Level of efficiency obtained by each DMU in the analysis period (DEA CCR-I model)

DMUs	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	0.9552	0.9876	0.988	0.8585	0.9078	0.8876	0.8132	0.9398
3	0.7793	1	1	1	1	1	0.9842	1	0.8576	1	0.9621
4	0.4773	0.4986	0.7026	0.7185	0.7027	0.7314	0.7851	0.6594	0.6624	0.6234	0.6561
5	0.4706	0.6529	0.8316	0.5641	0.6457	0.634	0.6967	0.7522	0.7615	0.743	0.6752
6	0.8218	0.7291	0.7345	0.8586	1	1	1	1	1	1	0.9144
7	0.6901	1	0.8926	0.7452	0.7379	0.7243	0.7398	0.7974	1	0.81	0.8137
8	0.6307	0.8078	0.9574	0.9558	0.804	0.7429	0.7001	0.7469	0.7912	0.9847	0.8122
9	0.5023	0.5296	0.6427	0.6796	0.646	0.727	0.6431	0.7637	0.6767	0.6654	0.6476
10	0.449	0.4833	0.5263	0.4686	0.5271	0.5478	0.5696	0.5792	0.5545	0.6251	0.5331
11	0.5453	0.5821	0.7017	0.8187	0.735	0.7749	0.7476	0.7457	0.6905	0.7437	0.7085
12	0.8756	0.9046	0.9529	1	1	1	1	1	1	1	0.9733
13	0.6387	0.7265	0.7575	0.7696	0.8009	0.7812	0.6691	0.6807	0.7107	0.761	0.7296
14	0.5983	0.5642	0.6796	0.5982	0.6449	0.6075	0.5367	0.6071	0.5116	0.4933	0.5841
15	0.783	1	0.9937	0.7772	0.7451	0.7786	0.5907	0.6356	0.6021	0.5775	0.7484
16	0.6303	0.6407	0.7239	0.741	0.7965	0.8189	0.6592	0.5964	0.8261	0.6416	0.7075
17	0.4751	0.7196	0.9041	0.6901	0.7011	0.735	0.7673	0.7946	0.8045	0.7597	0.7351
18	1	0.7006	0.8706	0.9947	0.5625	0.4629	0.8251	0.4481	0.6144	0.7525	0.7231
Promedio	0.6871	0.7522	0.8262	0.7964	0.7798	0.7808	0.7652	0.7619	0.7751	0.7775	0.7702

Source: Own elaboration with data from the SEPS (2007-2016)

In the efficiency analysis of the 18 CUs during the period of 2007-2016, we can observe that in the year of 2008 there was a greater number of credit unions that were 100% efficient with a total of five of them. There is only one fully efficient credit union in the ten years of analysis, with it being CU1 (*Cooperativa Juventud Ecuatoriana Progresista*). The lowest number of fully efficient credit unions is equally present in several of the years of analysis (2007, 2009, 2010, and 2013) with a total of three efficient credit unions in each year. The lowest levels of efficiency that have been obtained in the analysis period were present in 2007, where two credit unions reached efficiency levels that were inferior to 50%. For this reason, the lowest efficiency average is present in this year. Similarly, there are cases where the efficiency level has had a behavior that varies greatly; such is the case of CU18, which in 2007 happened to be 100% efficient, while in 2014 it obtained the lowest level of all CUs in the analyzed period. On the other hand, we have the case of CUs 16 and 14, which maintained an efficiency level that was relatively low in the first years, but which then reached an optimal level of efficiency and maintained it until the end of the period.

Case comparison

The efficiency ratios obtained for each DMU allowed to determine the CU groups that were fully efficient and those that were less efficient. Therefore, we were able to compare these groups through the observation of the clearances presented by each variable; defining clearance as the difference between one and the efficiency ratio obtained by each Credit Union.

The comparison analysis of the levels of increase or decrease of clearances will allow having a better understanding of the results.

Tables 7 and 8 show the quantities and percentages of increase or decrease that each variable must have had in order to be efficient.

Table 7
Projection of increase or decrease in the value of input variables (year 2007)

		OC			UF		
DMU	Efficiency	Data	Projection	Diff. (%)	Data	Projection	Diff. (%)
3	0.7793	7034.09	2944.46182	-58.14	2469.14	1924.22405	-22.069
4	0.4773	1768.58	844.204349	-52.266	1818.76	868.156579	-52.266
5	0.4706	3403.1	1601.58502	-52.938	5646.44	2176.65586	-61.451
6	0.8218	4489.04	2488.84253	-44.557	1965.68	1615.4754	-17.816
7	0.6901	4242.89	2927.85106	-30.994	6231.1	4013.27661	-35.593
8	0.6307	2148.68	1355.0857	-36.934	2316.9	1461.17568	-36.934
9	0.5023	2408.94	1110.97879	-53.881	1441.05	723.862048	-49.769
10	0.449	3195.02	1434.47798	-55.103	2798.63	1256.51092	-55.103
11	0.5453	2811.33	1532.88761	-45.475	1939.02	1057.25704	-45.475
12	0.8756	771.032	675.085572	-12.444	678.007	593.636498	-12.444
13	0.6387	1931.69	1145.62471	-40.693	1170.75	747.768275	-36.129
14	0.5983	2686.89	1587.79122	-40.906	1735.67	1038.41895	-40.172
15	0.783	2004.5	1172.93173	-41.485	989.56	774.812599	-21.701
16	0.6303	1941.54	713.050486	-63.274	739.226	465.902704	-36.974
17	0.4751	917.862	436.061934	-52.492	1337.56	591.956414	-55.744

Source: Own elaboration with data from the SEPS (2007-2016)

Table 8
Projection of increase or decrease in the value of the output variables (year 2007)

		AR			TD		
DMU	Efficiency	Data	Projection	Diff. (%)	Data	Projection	Diff. (%)
7	0.6901	778.737	892.10993	14.559	72630.3	72630.333	0
10	0.449	212.072	301.87201	42.344	30331.6	30331.631	0

Source: Own elaboration with data from the SEPS (2007-2016)

The clearance results presented correspond to the year 2007, which was taken as an example for the explanation of the same. In this case, it is necessary to indicate that the level of projections of the variables changes for the CUs every year of the period of analysis due to the variability of the set of data. The percentage of differences shown in Table 7 has a negative sign due to the model used, same which, as explained before, is oriented towards the minimization of inputs. Thus, in the case of CU 16, for example, it needs to decrease its Operation Costs by 63.27% and its Uncollectable Funds by 36.97% to be efficient. In turn, Table 8 shows positive clearance percentages due to the increase that these variables must have so that Credit Unions can operate in the optimal frontier. It can be observed in the output projections that only two Credit Unions, 7 and 10, must increase their percentages of the Accounts Receivable variable, while their Total Deposits variable is working just fine.

Sensitivity analysis

The model was executed considering the variations proposed for each of the variables and their percentage differences presented in Table 7. Table 9 shows the efficiency variations

http://dx.doi.org/10.22201/fca.24488410e.2018.1449

reached by each DMU when adjusting the data. It can be observed that it is important to focus on avoiding or minimizing clearances in the input variables, especially concerning Operation Costs. The correct handling of these will significantly increase the efficiency of the sector and in each DMU.

Table 9
Sensitivity analysis, variation of efficiencies by DMU. Year 2016

DMUs	Initial efficiency	OC Efficiency adjustment	UF Efficiency adjustment	AR Efficiency adjustment	TD Efficiency adjustment
1	1	1	1	1	1
2	0.8132	1	0.8971	0.8132	0.8132
3	1	1	1	1	1
4	0.6234	1	0.7683	0.6234	0.6234
5	0.743	0.9674	0.8486	0.743	0.743
6	1	1	1	1	1
7	0.81	1	0.8952	0.81	0.81
8	0.9847	0.9874	0.9972	0.9847	0.9847
9	0.6654	1	0.833	0.6654	0.6654
10	0.6251	0.8854	0.8016	0.6251	0.6251
11	0.7437	0.8766	0.9278	0.7437	0.7437
12	1	1	1	1	1
13	0.761	0.8888	0.8501	0.761	0.761
14	0.4933	0.9715	0.711	0.4933	0.4933
15	0.5775	1	0.7657	0.5775	0.5775
16	0.6416	0.9309	0.892	0.6416	0.6416
17	0.7597	1	0.9556	0.7597	0.7597
18	0.7525	0.841	0.9513	0.7525	0.7525
Average	0.7775	0.9638	0.8941.	0.7775	0.7775

Source: Own elaboration with data from the SEPS (2007-2016)

Using this logic, the model was executed using the corresponding adjustments for each year. Table 10 shows the average efficiency results by year. The need to make adjustments in the Operation Costs and Uncollectable Funds variables is confirmed. Any effort done in the output variables will not alter the efficiency results.

Table 10.
Sensitivity analysis, variation of the average efficiencies per year.

YEAR	Initial efficiency	OC Efficiency adjustment	UF Efficiency adjustment	AR Efficiency adjustment	TD Efficiency adjustment
2007	0.6871	0.9098	0.9058	0.6871	0.6871
2008	0.7522	0.9164	0.8895	0.7522	0.7522
2009	0.8262	0.9703	0.8814	0.8262	0.8262
2010	0.7964	0.9077	0.8937	0.7964	0.7964
2011	0.7798	0.9174	0.8422	0.7798	0.7798
2012	0.7808	0.9084	0.8556	0.7808	0.7808
2013	0.7652	0.9066	0.8665	0.7652	0.7652
2014	0.7619	0.8798	0.8857	0.7619	0.7619
2015	0.7751	0.9	0.9089	0.7751	0.7751
2016	0.7775	0.9638	0.8941	0.7775	0.7775

Source: Own elaboration with data from the SEPS (2007-2016)

Table 11 shows the variables that obtained a greater number of projections of increase or decrease in clearances for each year. For this, we considered indicating those variables that present a number of three projections and above as more effective.

Table 11
Variables with a greater number of projections in the period of analysis

Variables / Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Inputs										
Operation Costs (OC)	X	X	X	X	X	X	X	X	X	X
Uncollectable Funds (UF)	X	X	X	X	X	X	X	X	X	X
Outputs										
Accounts Receivable (AR)				X				X	X	X
Total Deposits (TD)			X	X	X	X	X			X

Source: Own elaboration with data from the SEPS (2007-2016)

We can observe from this analysis that the variables were less effective in 2010 and 2016, given that these years presented an adjustment projection in the four variables. Similarly, the years that present less projection variables are 2007 and 2008. It can be observed that the input variables were deficient throughout the period of analysis, so that it may be assumed that in order to obtain better efficiency ratios, credit unions must implement improvement plans for the reduction of operation costs, in addition to improving credit guarantee to consolidate a lower risk in the recovery of funds.

Table 12 indicates the comparison of each credit union determined as inefficient, with their efficient counterparts.

Table 12
Comparison of inefficient CUs with their efficient counterparts (year 2007)

DMU	Efficiency	Reference		
3	0.7793	DMU1	DMU18	
4	0.4773	DMU1	DMU2	DMU18
5	0.4706	DMU2	DMU18	
6	0.8218	DMU1	DMU18	
7	0.6901	DMU2		
8	0.6307	DMU1	DMU2	DMU18
9	0.5023	DMU1	DMU18	
10	0.449	DMU1	DMU2	
11	0.5453	DMU1	DMU2	DMU18
12	0.6387	DMU1	DMU18	
13	0.8756	DMU1	DMU 2	DMU18
14	0.5983	DMU1	DMU18	
15	0.783	DMU*1	DMU18	
16	0.4751	DMU 2	DMU18	
17	0.6303	DMU 1	DMU18	

Source: Own elaboration with data from the SEPS (2007-2016)

Conclusions

Once the Technical Efficiency analysis applied to the credit unions from “Segment 1” of the Ecuadorian credit union ranking in the period of 2007-2016 has been concluded through the use of the Data Envelopment Analysis (DEA), we obtained the efficiency level of the same,

determining that throughout the period of analysis there was a variation in the total number of efficient CUs of each year. For example, the year in which there was a greater number of efficient DMUs was 2008, with 5 credit unions. The lowest number of efficient credit unions was 3 in the years 2007, 2009, 2010, and 2013. There is only one CU that was fully efficient throughout the 10 years of analysis, CU 1 (*Juventud Ecuatoriana Progresista*).

The contribution of this study allows observing the increase or decrease projections in the values of the variables so that it is possible to know the area of improvement of each CU. To this end, we have presented all the data of the result of the analysis online, where any interested party may access said information through the following link:

https://drive.google.com/drive/folders/0B_2_YW0EYyP8c0F1cjFMTnBsM28?usp=sharing

The results of this study indicate that different types of analysis can be used, and we can measure the efficiency of any type of financial institution (banks, credit unions, others) in the different segments in Ecuador. Furthermore, with the results obtained, it is possible to implement improvements in the financial management of their input and output variables so that they can optimize their resources until they are fully efficient. However, CUs must prioritize the adjustment of input variables (OC and UC) given that these changes will represent significant increases in the efficiency of each analysis unit.

One of the main causes of inefficiency in the case studies is the high level of operation costs and the loss of money in uncollectable funds, which can be improved with the proper management and use of resources, which would represent savings, in addition to the implementation of proper computer systems that may speed up the process and with it reduce the excessive personnel expenses. For the case of uncollectable funds, it is necessary to improve the warranties for the granting of credits, to coordinate, and to properly review the information of each client with the Risk Central.

Through the use of not only the CCR-I model but also the different models presented by the Data Envelopment Analysis, it is possible to carry out studies that show deeper comparisons and analyses of the results obtained with the implementation of more than one model for the same set of data and analyze the variability or sensitivity that may be obtained in the results.

In a comparison of the level of efficiency obtained for each credit union vs the size of the same, we can assert that not necessarily the biggest credit unions turn out to be the most efficient.

References

Andrieş, A. M., & Cocriş, V. (2010). A comparative analysis of the efficiency of Romanian banks. *Romanian Journal of Economic Forecasting*, 13(4), 54–75.

Asawaruangpipop, P., & Suwunnamek, O. (2014). Analysis on Savings and Credit Cooperatives Efficiency in Coop Credit Thailand: A Data Envelopment Analysis (DEA) Approach. *Research Journal of Business Management.* http://doi.org/10.3923/rjbm.2014.242.253

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science*, 30(9), 1078–1092. http://doi.org/10.1287/mnsc.30.9.1078

Belmonte, L., & Plaza, J. (2008). Análisis de la eficiencia en las cooperativas de crédito en España. Una propuesta metodológica basada en el análisis envolvente de datos (DEA). *CIRIEC-España, Revista de Economía Pública, Social Y Cooperativa,* (63), 113–133. Retrieved from http://www.ciriec-revistaeconomia.es/banco/6305_Belmonte_y_Plaza.pdf

Benavides, R., & García, C. (2014). *Eficiencia en la Banca Múltiple peruana, mediante la aplicación del Análisis Envolvente de Datos DEA, en el período 2003-2012.* Universidad Nacional Agraria La Molina.

Boussofiane, A., Dyson, R. G., & Thanassoulis, E. (1991). Applied data envelopment analysis. *European Journal of Operational Research*, 52(1), 1–15. http://doi.org/10.1016/0377-2217(91)90331-O

Charnes, A., Cooper, W., Lewin, A., & Seiford, L. (1994). *Data envelopment analysis: Theory, methodology and applications.* Boston: Kluwer Academic Publishers.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2(6), 429–444. http://doi.org/10.1016/0377-2217(78)90138-8

Coll, V., & Blasco, O. (2006). *Evaluacion De La Eficiencia Mediante El Analisis Envolvente De Datos Introducción a Los Modelos Básicos.* (Universidad de Valencia, Ed.). Retrieved from http://www.eumed.net/libros-gratis/2006c/197/

Farrel, M. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society,* 120(3), 253–290.

Favero, C., & Papi; L. (1995). Technical efficiency and scale efficiency in the Italian banking sector: A non- parametric approach. *Applied Economics*, 27(4), 385–395. http://doi.org/http://dx.doi.org/10.1080/00036849500000123

Joseph, J., & Pastory, D. (2013). Technical Efficiency of the Rural Savings and Credits Cooperative Societies in Tanzania: A DEA Approach. *International Journal of Management Sciences and Business Research,* 2(12), 49–61.

Lemos, D., Seido, M., & Monforte, E. (2007). Aplicação da Análise Envoltória de Dados em Cooperativas de Crédito Rural. *RAC*, 2, 99–120. Retrieved from http://www.spell.org.br/documentos/ver/18077/aplicacao-da-analise-%09envoltoria-de-dados-em-cooperativas-de-credito-rural

Lindley, J., & Sealey, C. W. (1977). Inputs, Outputs, and a Theory of Production and Cost at Depository Financial Institutions. *The Journal of Finance*, 32(4), 1251–1266.

Marrero Ancízar, Y., & Ortíz Torres, M. (2016). Procedimiento para medir la eficiencia técnica de los negociadores comerciales mediante el análisis envolvente de datos (AED). *Economía Y Desarrollo*, 157(2), 147–165.

Miño, W. (2013). *Historia del Cooperativismo en el Ecuador.* (E. S.A, Ed.). Quito.

Moreno Sierra, V. C., & Rey Huertas, L. E. (2017). Análisis de la eficiencia en las Cooperativas de Ahorri y Crédito en Colombia, mediante la utilización de la Técnica de Datos Envolvente.

Navarro, J., & Torres, Z. (2006). Análisis de eficiencia técnica global mediante la metodología DEA: evidencia empírica de la industria eléctrica mexicana en su fase de distribución, 1990-2003. *Revista Nicolaita de Estudios Económicos*, 1(1), 9–28.

Pedraja, F., & Salinas, J. (1996). Eficiencia del gasto público en educación secundaria: una aplicación de la técnica envolvente de datos. *Hacienda Pública Española*, 138(3), 87–95.

Restrepo, M. I., & Villegas, J. G. (2011). Análisis Envolvente de Datos : Introducción y herramienta pública para su utilización Palabras Clave :, 27. Retrieved from https://juangvillegas.files.wordpress.com/2013/08/restrepo-villegas-dea.pdf

Santana Ramírea, M. A. (2015). *El sistema financiero de la República Dominicana*. Universitat de Valencia.

SEPS. (2016). Superintendencia de Economía Popular y Solidaria. Retrieved from http://www.seps.gob.ec/estadisticas?boletines-mensuales-de-segmento-1

Tortosa, E. (2002). Bank cost efficiency and output specification. *Journal of Productivity Analysis,* 18(3), 199–222. http://doi.org/10.1023/A:1020685526732

Valencia, L. S., & Chediak, F. (2008). Metodología para medir la Eficiencia mediante la Técnica del Análisis Envolvente de Datos DEA. *Vector*, 3, 70–81.

Xueping, X., Jie, T., & Hongxin, R. (2011). A DEA-model evaluation of the efficiency of peasant household credit investigation system in rural credit cooperatives: A positive research in Hubei Province, China. C*hina Agricultural Economic Review*, 3, 54–65. http://doi.org/http://dx.doi.org/10.1108/17561371111103543