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Presentation of a Window Cross- Sectional Data Envelopment Analysis for Construction Projects' Credit Allocation



Abstract

Evaluating and studying efficiency is always one of the human needs to recognize its strengths and weaknesses points to have better efficiency by taking advantage of its strengths and covering its weaknesses. Efficiency evaluation has been converted into one of the fundamental concerns of organizations' managers in today's competitive conditions. Many researches have been conducted in this field due to the importance of evaluating and assessing organizations and people's efficiency, and researchers look at evaluation from different angles and present various methods for this purpose. To some extent, the window analysis method settles the observations' insufficiency problem in time evaluation by making the observation combination possible in time and cross-sectional series. So, four input indexes, including personnel, administrative, deposit, and overhead costs, and three output indexes, including deposit income, loan facility income, and fee income, were selected to assess banks' branches' efficiency using an interview with the experts and library study and subject literature review on order to evaluate bank branches' efficiency. Therefore, 45 bank branches were analyzed and evaluated according to the identified branches in the bank under study. In the conducted evaluation, the efficiency of 45 branches was firstly assessed using window cross-sectional data envelopment analysis, among which five branches were efficient. Branches' efficiency was first evaluated using the window CCR model to confirm the presented model, and then, they were ranked through the Anderson-Peterson method. The comparative results of intersecting efficiency and integration algorithm (super efficiency) were equal, and the model was confirmed.

Keywords: Data envelopment analysis, efficiency evaluation, constructive credits allocation

1. INTRODUCTION

In recent decades, managerial and academic literature has paid increasing attention to the organizational efficiency issue because it leads to personnel motivation, decision-making support, improvement in organizational learning, continuous improvement, and increased communication and coordination [1]. Efficiency improvement is one of the key issues of managers in the organizations. Most of the studies have emphasized the need for profitability and synchronization of the implemented operations and also the need to decrease the general costs. Efficiency evaluation is possible, especially in the public sector. It is practically (or for political reasons) impossible to assign a price to some produced goods and services [2]. Efficiency evaluation in the data envelopment analysis method is done in a relative form by comparing decision-making units (DMU) that necessarily fulfill one unit goal. DEA aims to investigate whether another comparable unit can be found that produces more output with the same amount of input or consumes less input to produce the same amount of output [3]. If such a DMU is found, it is fully obvious that the evaluated unit cannot perform in such a good way, assuming other conditions are maintained. In DEA, we do not need

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to clearly know the relationship between inputs and outputs. We just need to know the inputs and output values. DEA determines which units can improve their efficiency and which units' efficiency can be considered weak. Efficiency cannot be fully defined because we use multidimensional factors to measure efficiency. Efficiency means the success of the company or institution in producing as much output as possible of the production factors group with a fixed technology in such a way that all the output and inputs are carefully measured [4].

Considering the competitiveness of today's world, banks are also included in this category and efficiency discussion, and consequently, efficiency measurement is inevitable according to this issue. Evaluation of the organizations' efficiency, especially banks, is one of the most important issues in the management field. The data envelopment analysis technique is a powerful tool for evaluating organizations considering multiple input and output indexes. Traditional data envelopment analysis models only evaluate efficiency over time and ignore the time factor as one of the most important factors influencing efficiency. Data envelopment analysis is considered one of the fastest-growing fields of management and research science in operations, and it is used to evaluate the organizations' efficiency in the private and public sectors [5]. To some extent, the window analysis method, by making it possible to combine observations in time and cross-sectional series, solves the problem of insufficient observations in time evaluations. This technique works based on moving averages, and it is useful for finding the efficiency processes of a unit over time. Each unit is treated as an independent unit in a different period. In this case, the efficiency of a unit in a specific period is evaluated against the efficiency of that unit in other periods in addition to the efficiency of other units. This situation increases the number of periods under study in the analysis, which is useful when small sample sizes are under examination. A change in the window's width, which means the number of periods, shows the provision of a range of simultaneous analyses, which only include observations of one time period, to cross-sectional analyses, which include some observations of all the studied periods. Investment in construction projects is one of the banks' success components [6].

Therefore, the allocation of construction budgets in banks has always taken special attention as one of the important stages for the banking units' growth, and a special procedure has been considered for this purpose based on the items desired by managers in different periods. Therefore, investigating this issue using different methods of this resource allocation's efficiency can greatly help to continue or modify this method. Therefore, it is worth avoiding wasting resources and ensuring their optimal allocation by examining the various units' efficiency, comparing the allocations with the units and their efficiency, and presenting a new method of resource allocation based on the ideal planning of efficient and inefficient units. So, this research has tried to assess each unit's efficiency through the data envelopment analysis method to present new, optimal, and applicable guidelines relating to these resources allocation in budgeting and the manner of their allocation with the aim of optimal allocation of bank's constructive credits to different units (branch).

2. LITERATURE REVIEW

Omrani has compared and evaluated 52 bank branches' efficiency in his research and applied two methods, including data envelopment analysis (DEA) and financial ratio (ACC), to evaluate the above branches and compare them together. The research's main purpose includes comparison and evaluation of efficiency assessment methods, efficiency level measurement based on a quantitative criterion, identification of variables and effective ratios in efficiency measurement, and finding the relationship and closeness of the bank's current evaluation method with two other methods in each branch. Esmaeeli et al. [7] has applied a balanced scorecard based on four perspectives as an efficiency evaluation model for bank branches in his research, and the importance of each perspective and criteria of two more important perspectives were determined as the research's main components by using a questionnaire. Through the questionnaire analysis, financial and customer perspectives have been considered the most important using the pairwise comparison technique. 6 criteria for financial perspective and three criteria for customer perspective separated by output and input were determined from 45 primary criteria. All the 54 branches under study were scored and finally ranked according to the input-oriented BCC model, assuming returns to a variable scale using the data envelopment analysis (DEA) technique and DEAP software modeling. Izadikhah [8] presented a new methodology in

his self-evaluation study of banks' branches in this field. This methodology is based on the application of network data envelopment analysis. The bank's input and output factors were categorized in this technique at different levels in such a way that one level's output can be another level's input. We actually tried this technique to evaluate the bank's branches based on intra-branch efficiency level and assess them compared with other branches. In continuation, some guidelines have been presented by recognizing efficient and inefficient units to convert inefficient units to efficient ones at different levels. Fukuyama and Tan [9] has evaluated and ranked the banks' efficiency using the data envelopment analysis technique in his research.

This research also reports that the impact of corporate risk management on bank efficiency is more significant for large banks and also the banks that work independently in an uncertain environment with higher complexity and less supervision of the board of directors. This research provides some empirical evidence on the relationship between corporate risk management and bank efficiency for small banks and banks with an uncertain environment, higher complexity, and less supervision by the independent board of directors. This article presents a Brazilian telecommunications company to investigate and express the integration of the balanced scorecard (BSC) (which is a multiple perspective framework for efficiency evaluation) and the analytical hierarchy process (AHP) (which is a decision-making tool for prioritizing multiple efficiency perspective and indexes and presentation of a unique standard for the options ranking) (In this case, operational units' efficiency). The interaction and repetition method, along with an approach, is for agreeing with managers to establish priority values for efficiency dimensions and related indexes. This article discusses the advantages and disadvantages of designing this method.

On the other hand, Tavana et al. [10] showed that the two-stage DEA model can only be used for efficiency evaluation systems, which are specified with a positive input to validate the new mathematical envelopment analysis model. While data can have negative values in real-world conditions, they presented a new suggestion in which they used range direct measurement for two-stage models of DEA that also provide negative data for them. Both of them were desirable and undesirable. They analyzed the main features of the newly introduced model. The one-step dynamic model considers the DMU activities as a black box that ignores intermediate criteria. Therefore, the internal relationships that play a key role in the production process of each unit, for example, the operational income variables, operating margin, operational cash flows, and loan deposits, are completely ignored. In his research, Guo and Zhu [11] stated that literature on linear fractional non-participative networks for two-stage network structures in the data envelopment analysis literature (DEA) is often converted into parametric linear models. The transformed parametric linear models are then solved by computing a series of linear models when the parameters are changed. For example, Wu et al. [12] provide a linear fractional non-participative DEA to analyze the reuse of undesirable intermediate outputs in a two-stage manufacturing process with common resources and feedback. They transformed the linear partition model into a parametric linear model.

Such approaches do not guarantee that the global optimal solution will be found. They have shown that (types) linear non-participatory network DEA models can be directly transformed into linear programming models without solving linear parametric models. This significantly reduces the computational burden, and the global optimal solution is always guaranteed. Zhou et al. [13] proposes two limited-quadratic DEA models to evaluate the efficiency of mutual funds from the perspective of evaluation based on internal benchmarks. Compared with previous studies, this paper analyzes two fundamental factors for mutual funds' efficiency, including risk and return, to define the mutual funds' internal benchmarks and provide insights and suggestions for management. Among the two limited quadratic DEA models, one partially limited-quadratic programming model is controllable. This approach is shown with a sample of twenty-five mutual funds active in the Chinese market.

According to the evaluation of the research literature and the past articles, it was observed that most of the studies had been conducted in the field of efficiency and data coverage analysis in the fields of management, industries, and mathematics to investigate the different units' efficiency and aimed to achieve the best and worst unit. Based on the observed research gap, this research has tried to examine the most optimal input and output factors to achieve more accurate efficiency, and the results of this efficiency are compared through different other methods of efficient unit

selection such as bank evaluations and resource allocation based on efficiency so that the advantage of each method can be evaluated. The research has innovative directions regarding the resource allocation evaluation based on these factors and examining the simultaneity of this issue in construction and construction management and the selection of input and output factors related to the banks' construction budget.

3. PROBLEM DESCRIPTION

The main issue in this research is evaluating the country's banks' efficiency using the combining window data envelopment analysis approach. Data envelopment analysis is one of the most common tools used to calculate the efficiency of decision-making units. However, this tool cannot alone consider the conditions of cooperation between units. Therefore, it is necessary to add another powerful tool to data envelopment analysis to calculate the efficiency of units in a situation where cooperation between units is formed through the value that each effective decision-making unit creates in different coalitions and observe its impact on the efficient units ranking.

The approach of data envelopment analysis models' development to increase the accuracy in evaluating the efficiency of DMUs is the application of the two-stage analysis method. In the first stage of this approach, indexes with a lower degree of importance of DMUs are evaluated, and so-called initial screening is performed with a simpler degree of strictness. In the final stage of screening, according to the introduced key indexes, the efficiency of DMUs is evaluated, and the most efficient DMUs are identified and introduced in this stage in terms of key indexes. Therefore, according to Cao and Huang's method, each DMU consists of two subunits in series, and its overall efficiency can be analyzed as the product of the efficiency of the two subunits. Therefore, the mathematical method presented in this research is input-oriented CCR, which deals with the initial evaluation of DMUs according to the following formula.

$$\theta_p = \max \sum_{d=1}^D w_d z_{dp} \tag{1}$$

s.t

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

$$\sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} \leq 0, \quad \forall j = 1, \dots, n;$$

$$\sum_{d=1}^D w_d z_{dj} - \sum_{i=1}^m v_i x_{ij} \leq 0, \quad \forall j = 1, \dots, n;$$

$$\sum_{r=1}^s u_r y_{rj} - \sum_{d=1}^D w_d z_{dj} \leq 0 \quad \forall j = 1, \dots, n;$$

$$u_r, v_i, w_d \geq \epsilon, \quad r = 1, \dots, s; i = 1, \dots, m; d = 1, \dots, D.$$

Therefore, their final screening will be done using Za and Liang's method after the first stage evaluation of DMUs in the second stage. For these types of process modeling, an assignment factor α_i was assigned to each input value X_{ij} from a DMU j . The factor α_i divides the input value x_{ij} into two parts, $\alpha_i x_{ij}$ and $x_{ij} (1-\alpha_i)$, which are used as inputs in the first and second stages, respectively.

$$\theta_p = \max \sum_{d=1}^D w_d z_{dp} \times \sum_{r=1}^s u_r y_{rp} \tag{2}$$

s. t .

$$\sum_{i=1}^m \pi_i x_{ip} = 1,$$

$$\delta \left[\sum_{i=1}^m (v_i - \pi_i)x_{ip} + \sum_{d=1}^D w_d z_{dp} \right] = 1,$$

$$\sum_{r=1}^s u_r y_{rj} - \delta \left[\sum_{i=1}^m (v_i - \pi_i)x_{ij} + \sum_{d=1}^D w_d z_{dj} \right] \leq 0,$$

$$j = 1, \dots, n;$$

$$\sum_{d=1}^D w_d z_{dj} - \sum_{i=1}^m \pi_i x_{ij} \leq 0,$$

$$j = 1, \dots, n;$$

$$v_i \geq \pi_i \geq 0, \quad \forall i = 1, \dots, m.$$

$$u_r, w_d \geq \varepsilon, \quad r = 1, \dots, s; d = 1, \dots, D.$$

According to the two-stage disconnection of the o data envelopment analysis implementation method of Kao and Huang and Zha and Liang, therefore, according to the evaluations of the Leader and Piro models in the two-stage efficiency evaluation models, Izadikhah et al. [14] finally presented the following final model through an integrated two-stage evaluation approach of DMUs based on the input-oriented CCR approach by which they will evaluate the efficiency of DMUs in the banking industry (Figure 1).

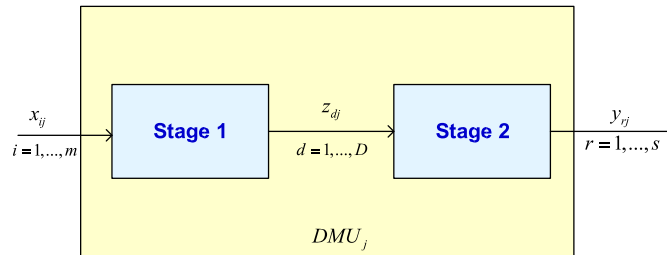


Figure 1. The efficiency of DMUs in the banking industry.

$$\theta_{2p}^L = \max \sum_{r=1}^R u_r^2 y_{rp}^2 \tag{3}$$

s. t.

$$\sum_{k=1}^K v_k^3 x_{kp}^3 + \sum_{t=1}^T v_t^2 (1 - \alpha_t) x_{tp}^2 + \sum_{d=1}^D w_d^1 z_{dp}^1 + \sum_{b=1}^B w_b^2 z_{bp}^2 = 1,$$

$$\sum_{r=1}^R u_r^2 y_{rp}^2 - \sum_{k=1}^K v_k^3 x_{kp}^3 - \sum_{t=1}^T (v_t^2 - \mu_t^2) x_{tp}^2 - \sum_{d=1}^D w_d^1 z_{dp}^1 - \sum_{b=1}^B \varphi_b^2 z_{bp}^2 \leq 0,$$

$\forall j = 1, \dots, n,$

$$\sum_{d=1}^D w_d^1 z_{dp}^1 + \sum_{b=1}^B w_b^2 z_{bp}^2 + \sum_{h=1}^H u_h^1 y_{hp}^1 - \theta_{1p}^{U*} \left(\sum_{i=1}^I v_i^1 x_{ip}^1 + \sum_{t=1}^T \mu_t^2 x_{tp}^2 \right) = 0,$$

$$\sum_{d=1}^D w_d^1 z_{dj}^1 + \sum_{b=1}^B w_b^2 z_{bj}^2 + \sum_{h=1}^H u_h^1 y_{hj}^1 - \sum_{i=1}^I v_i^1 x_{ij}^1 - \sum_{t=1}^T \mu_t^2 x_{tj}^2 \leq 0,$$

$$j = 1, \dots, n,$$

$$w_d^1, w_b^2, u_r^3, v_k^3, v_t^2, u_h^1, v_j^1, \mu_t^2, \varphi_b^2 \geq 0, \quad d = 1, \dots, D;$$

$$b = 1, \dots, B; r = 1, \dots, s; k = 1, \dots, K;$$

$$h = 1, \dots, H; i = 1, \dots, I; t = 1, \dots, T.$$

$$0 \leq \mu_t^2 \leq v_t^2, \quad t = 1, \dots, T,$$

$$0 \leq \varphi_b^2 \leq w_b^2, \quad b = 1, \dots, B.$$

Now, we can evaluate a two-stage production process by taking advantage of collaborative productivity in which each (dmu) consists of two subsets in a series described by characteristics. According to the models presented in the previous sections and the previous model's analysis method, the following fractional programming model has been suggested to determine the overall effectiveness of the overall θ_p (p-dump).

$$\theta_p = \max \frac{\sum_{d=1}^D w_d^1 z_{dp}^1 + \sum_{b=1}^B w_b^2 z_{bp}^2 + \sum_{h=1}^H u_h^1 y_{hp}^1}{\sum_{i=1}^I v_i^1 x_{ip}^1 + \sum_{t=1}^T v_t^2 (\alpha_t x_{tp}^2)} \times \frac{\sum_{r=1}^R u_r^2 y_{rp}^2}{\sum_{k=1}^k v_k^3 x_{kp}^3 + \sum_{t=1}^T v_t^2 (1 - \alpha_t) x_{tp}^2 + \sum_{d=1}^D w_d^1 z_{dp}^1 + \sum_{b=1}^B w_b^2 (\beta_b z_{bp}^2)} \tag{4}$$

S.t.

$$\frac{\sum_{d=1}^D w_d^1 z_{dj}^1 + \sum_{b=1}^B w_b^2 z_{bj}^2 + \sum_{h=1}^H u_h^1 y_{hj}^1}{\sum_{i=1}^I v_i^1 x_{ij}^1 + \sum_{t=1}^T v_t^2 (\alpha_t x_{tj}^2)} \leq 1, \quad \forall j = 1, \dots, n,$$

$$\frac{\sum_{r=1}^R u_r^2 y_{rj}^2}{\sum_{k=1}^k v_k^3 x_{kj}^3 + \sum_{t=1}^T v_t^2 (1 - \alpha_t) x_{tj}^2 + \sum_{d=1}^D w_d^1 z_{dj}^1 + \sum_{b=1}^B w_b^2 (\beta_b z_{bj}^2)} \leq 1, \quad \forall j = 1, \dots, n,$$

$$w_d^1, w_b^2, u_r^3, v_k^3, v_t^2, v_i^1, u_h^1 \geq 0, \quad \forall d = 1, \dots, D; b = 1, \dots, B; r = 1, \dots, s; k = 1, \dots, K; t = 1, \dots, T; i = 1, \dots, I; h = 1, \dots, H.$$

$$0 \leq \alpha_t \leq 1, \quad \forall t = 1, \dots, T,$$

$$0 \leq \beta_b \leq 1, \quad \forall b = 1, \dots, B.$$

Model (4) can be converted into the following model using Charnes-Cooper transformation and adjustments ($\beta_b = w_b^2$ φ_b^2 ($v_t^2 \alpha_t = \mu_t^2$))

$$\theta_p = \max \left(\sum_{d=1}^D w_d^1 z_{dp}^1 + \sum_{b=1}^B w_b^2 z_{bp}^2 + \sum_{h=1}^H u_h^1 y_{hp}^1 \right) \times \left(\sum_{r=1}^R u_r^2 y_{rp}^2 \right) \tag{5}$$

s.t.

$$\sum_{i=1}^I v_i^1 x_{ip}^1 - \sum_{t=1}^T \mu_t^2 x_{tp}^2 = 1,$$

$$\sum_{k=1}^k v_k^3 x_{kp}^3 + \sum_{t=1}^T (v_t^2 - \mu_t^2) x_{tp}^2 + \sum_{d=1}^D w_d^1 z_{dp}^1 + \sum_{b=1}^B \varphi_b^2 z_{bp}^2 = 1,$$

$$\sum_{d=1}^D w_d^1 z_{dj}^1 + \sum_{b=1}^B w_b^2 z_{bj}^2 + \sum_{h=1}^H u_h^1 y_{hj}^1 - \sum_{i=1}^I v_i^2 x_{ij}^2 - \sum_{t=1}^T \mu_t^2 x_{tj}^2 \leq 0, \quad \forall j = 1, \dots, n,$$

$$\sum_{r=1}^R u_r^2 y_{rp}^2 - \sum_{k=1}^k v_k^3 x_{kp}^3 - \sum_{t=1}^T (v_t^2 - \mu_t^2) x_{tp}^2 - \sum_{d=1}^D w_d^1 z_{dp}^1 - \sum_{b=1}^B \varphi_b^2 z_{bp}^2 \leq 0, \quad \forall j = 1, \dots, n,$$

$$w_d^1, w_b^2, u_r^2, v_k^3, v_t^2, v_i^1, u_h^1 \geq 0, \quad d = 1, \dots, D; b = 1, \dots, B; r = 1, \dots, R; k = 1, \dots, K; t = 1, \dots, T; i = 1, \dots, I; h = 1, \dots, H.$$

$$0 \leq \varphi_b^2 \leq w_b^2, \quad b = 1, \dots, B.$$

$$0 \leq \mu_t^2 \leq v_t^2, \quad t = 1, \dots, T,$$

Model (5) is a nonlinear programming subject as follows:

$$\theta_{1p}^L \leq \sum_{d=1}^D W_d^1 Z_{dp}^1 + \sum_{b=1}^B w_b^2 z_{bp}^2 + \sum_{h=1}^H u_h^1 y_{hp}^1 \leq \theta_{1p}^U \text{ and}$$

$$\theta_{2p}^L \leq \sum_{r=1}^R u_r^2 y_{rp}^2 \leq \theta_{2p}^U. \tag{6}$$

Therefore, according to the modification of the above model by Izadikhah et al. [14], the two-stage DMU evaluation approach is as follows:

$$\theta_p = \max \sum_{r=1}^R \tilde{u}_r^2 y_{rp}^2 \tag{7}$$

s. t.

$$\sum_{i=1}^I \tilde{v}_i^1 x_{ip}^1 + \sum_{t=1}^T \tilde{\mu}_t^2 x_{tp}^2 = \lambda,$$

$$\sum_{k=1}^K \tilde{v}_k^3 x_{kp}^3 + \sum_{t=1}^T (\tilde{v}_t^2 - \tilde{\mu}_t^2) x_{tp}^2 + \sum_{d=1}^D \tilde{w}_d^1 z_{dp}^1 + \sum_{b=1}^B \tilde{\varphi}_b^2 z_{bp}^2 = \lambda,$$

$$\sum_{d=1}^D \tilde{w}_d^1 z_{dp}^1 + \sum_{b=1}^B \tilde{w}_b^2 z_{bp}^2 + \sum_{h=1}^H \tilde{u}_h^1 y_{hp}^1 - \sum_{i=1}^I \tilde{v}_i^1 x_{ip}^1 - \sum_{t=1}^T \tilde{\mu}_t^2 x_{tp}^2 \leq 0,$$

$$j = 1, \dots, n,$$

$$\sum_{r=1}^R \tilde{u}_r^2 y_{rp}^2 - \sum_{k=1}^K \tilde{v}_k^3 x_{kp}^3 - \sum_{t=1}^T (\tilde{v}_t^2 - \tilde{\mu}_t^2) x_{tp}^2 - \sum_{d=1}^D \tilde{w}_d^1 z_{dp}^1 - \sum_{b=1}^B \tilde{\varphi}_b^2 z_{bp}^2 \leq 0,$$

$$\forall j = 1, \dots, n,$$

$$\lambda = \sum_{d=1}^D W_d^1 Z_{dp}^1 + \sum_{b=1}^B w_b^2 z_{bp}^2 + \sum_{h=1}^H u_h^1 y_{hp}^1,$$

$$\tilde{w}_d^1, \tilde{w}_b^2, \tilde{u}_h^1, \tilde{v}_i^1, \tilde{v}_t^2, \tilde{u}_h^1 \geq 0, \quad d = 1, \dots, D; b = 1, \dots, B; r = 1, \dots, R; k = 1, \dots, K; t = 1, \dots, T; i = 1, \dots, I; h = 1, \dots, H$$

$$0 \leq \tilde{\varphi}_b^2 \leq \tilde{w}_b^2, \quad b = 1, \dots, B.$$

$$0 \leq \tilde{\mu}_t^2 \leq \tilde{v}_t^2, \quad t = 1, \dots, T.$$

$$\theta_{ip}^L \leq \lambda \leq \theta_{ip}^U$$

According to the above-identified components, the symbol v is the input variable, u is the output variable, x is the input index of each step, and y is the output index. Another evaluation component is probability, which will be evaluated based on the experts' opinions on the Likert scale.

4. RESULTS

With respect to the conducted evaluation, the main investigated indexes in the banking industry are examined, which are as follows (Figure 2).

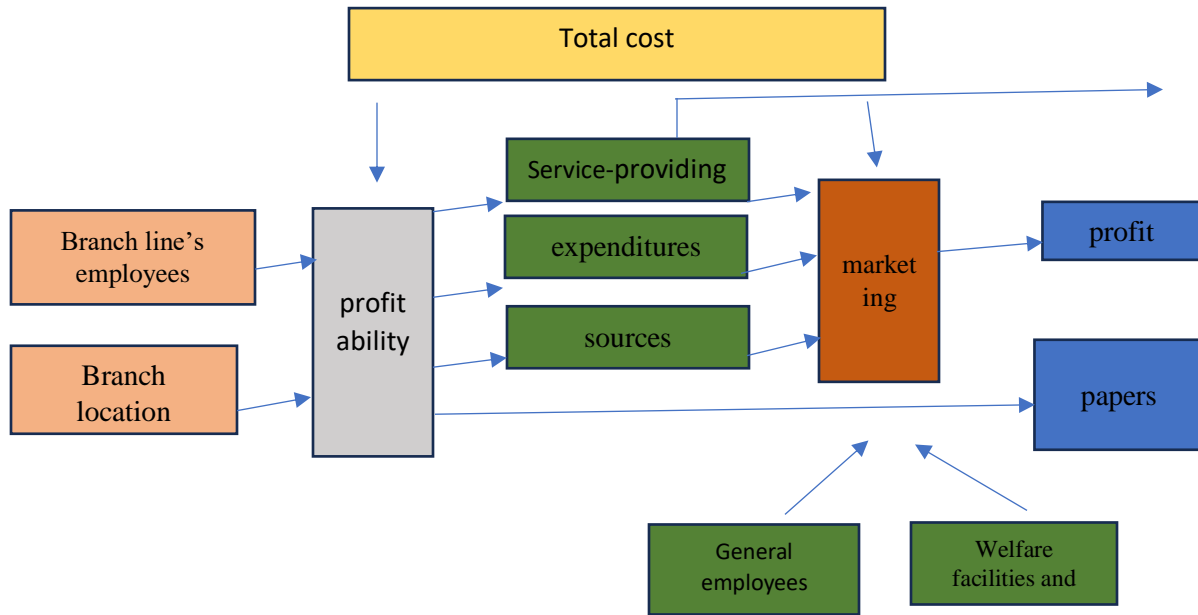


Figure 2. Research's conceptual model.

According to the conceptual model presented in this section, the bank branches' experts have been used to collect information which has either provided the branches' information for research or presented their expert opinions according to the Likert spectrum of tendencies in the form of completely agree, agree, have no opinion, disagree and completely disagree according to the considered indexes.

According to the two-stage input and output evaluation model for each DMU, the input and output items considered in each step are as follows:

Introducing the input indexes of the first stage:

4.1. The bank location

This index has been polled according to the research experts' opinion based on the five-choice Likert spectrum with the explanation that one is considered the worst bank location and five is for the best bank locations based on the matrix of pairwise comparisons.

4.2. Branch's employees

It is calculated and evaluated based on the number of effective line forces in banking operations, which has been recorded using the information contained in the branches' financial statements.

4.3. Providing service

This index is evaluated based on the service provided to customers during one month. These services include the number of registered documents, the number of account openings, the number of card issuances, the number of electronic service activations, and the number of sent transfer checks, which have been recorded using the information contained in the branches' financial statements.

4.4. Expenditures

This index is calculated based on the sources spent in branches to allocate credit to the customers. Expenditures include interest-free loans, facilities granted to individuals, customer debt in temporary debtors' accounts, facilities from foreign exchange reserves, debtors for letters of credit and long-term foreign exchange bills, advance payment for the purchase of property purchased for time-bargain and also obligations including guarantees and letters of credit issued by branches and the title of forging which have been recorded using the information contained in the branches' financial statements.

4.5. Sources

This index includes the funds that various individuals have deposited in the bank under the headings of current interest-free loan deposits, short-term current interest-free loan deposits and long-term investment deposits and long-term investment deposits which have deposited in the bank, and also the amount of sold bonds that registered using the information contained in the branches' financial statements.

Second stage input:

4.6. Employees

According to the information in the branches' financial statements, employees are registered based on the number of effective general staff in marketing operations and the bank's modern service providers as capital market services and insurance services.

4.7. Welfare facilities and equipment

It includes the facilities and resources installed in the branches for the customers' welfare, including the number of ATMs, the number of automatic cash receipts, automatic check receipts, automatic account opening machines, automatic card issuing machines, wireless internet, financial advice counter, insurance service counter, capital market service counter, modern banking service- provider counter, parking lot and the proximity of the branch to the city center

Outputs of the second stage:

4.8. Net profit

This index is evaluated and selected based on the profit earned by the branches in the financial statements of the branches.

4.9. Securities

This index includes trust partnership bonds, promissory notes, real estate securities, and securities of the check cashing group in the branches' securities headings and included in the branch's financial statements.

Common entry:

4.10. Costs

Including financial costs, personnel costs, the cost of doubtful receivables included in the financial statements

The collected data is described in Table 1.

Table 1. The data collected from the bank's branches.

dmu	X_1^1	X_2^1	X_2^1	X_1^2	X_1^3	X_2^3	Z_1^1	Z_2^1	Z_1^2	Y_1^1	Y_1^2
dmu1	2	8	14	14	4	35	570	70	3501	96	12
dmu2	3	5	15	15	0	30	700	95	2403	120	15
dmu3	4	8	20	20	3	40	850	128	2010	210	38
dmu4	1	4	10	10	0	20	510	800	1500	1050	14
dmu5	4	5	12	12	0	25	900	90	1709	120	10
dmu6	3	6	16	16	0	15	600	97	1200	150	18
dmu7	3	7	17	17	2	40	1200	3100	1870	4200	40
dmu8	1	8	21	21	1	15	850	65	3000	95	9
dmu9	4	6	16	16	4	30	980	110	3500	150	18
dmu10	3	5	13	13	1	20	780	78	870	110	18
dmu11	1	10	30	30	5	40	1150	700	4250	1120	45
dmu12	4	10	35	35	4	40	1000	750	4330	1200	35
dmu13	2	5	12	12	1	15	600	55	975	85	6
dmu14	2	6	18	18	0	15	620	78	760	105	17
dmu15	4	6	16	16	1	15	790	117	3760	220	29
dmu16	5	6	22	22	1	20	820	120	2760	250	19
dmu17	4	7	36	36	0	10	510	56	680	78	7
dmu18	5	5	25	25	0	10	710	95	3540	130	11
dmu19	4	8	31	31	2	15	830	220	2570	300	30
dmu20	3	7	22	22	1	20	890	90	3490	140	25
dmu21	5	4	14	14	1	25	910	180	1680	370	28
dmu22	1	3	13	13	1	30	654	97	1350	160	19
dmu23	5	4	8	8	0	15	450	45	755	68	4
dmu24	4	6	40	40	2	35	1250	150	3980	320	32
dmu25	3	7	15	15	2	35	783	520	1130	650	35
dmu26	4	5	6	6	1	15	594	88	877	171	9
dmu27	4	6	14	14	4	35	664	150	1360	210	18
dmu28	4	5	11	11	1	15	725	190	985	260	11
dmu29	2	14	62	62	7	55	1950	3000	3555	5100	64
dmu30	5	5	13	13	1	25	840	150	1890	260	25

dmu31	1	5	40	40	1	30	836	900	1655	1350	31
dmu32	3	4	15	15	1	15	550	780	2433	960	10
dmu33	2	5	11	11	2	15	840	150	2310	210	6
dmu34	4	5	17	17	3	45	452	220	2840	320	16
dmu35	5	6	16	16	1	15	865	145	3120	180	20
dmu36	5	7	45	45	3	40	1275	590	3110	880	38
dmu37	4	4	10	10	0	25	657	700	2380	850	19
dmu38	2	5	12	12	1	15	856	450	1604	620	16
dmu39	5	4	11	11	1	35	654	670	1308	960	22
dmu40	2	6	51	51	3	20	1002	225	3650	420	13
dmu41	5	6	13	13	1	35	700	270	988	350	10
dmu42	1	7	18	18	2	25	1100	2500	1240	4670	101
dmu43	2	5	14	14	2	15	678	70	876	250	11
dmu44	1	5	13	13	0	20	856	256	1238	380	17
dmu45	5	6	14	14	6	60	2450	5220	3910	7250	210

According to the data collected from 45 bank branches, the efficiency condition of 45 branches at the first and second stages is as follows with respect to the conducted two-stage data envelopment analysis model (Table 2).

Table 2. Two-stage analysis evaluation and macro-efficiency assessment based on Anderson method.

	Efficiency at the first stage	Efficiency at the second stage	Total efficiency	AP ranking	
DMU1	0.69543	0.11876	0.08259	0.08259	38
DMU2	0.66412	0.62448	0.41473	0.41473	8
DMU3	0.40344	0.34676	0.1399	0.1399	28
DMU4	0.75772	0.93942	0.71182	0.71182	3
DMU5	0.51255	0.54317	0.2784	0.2784	14
DMU6	0.3641	0.94823	0.34525	0.34525	10
DMU7	0.68214	0.40123	0.27369	0.27369	15
DMU8	0.7284	0.1375	0.10016	0.10016	34
DMU9	0.66762	0.13955	0.09317	0.09317	36
DMU10	0.48224	0.30575	0.14745	0.14745	25
DMU11	0.99985	0.44554	0.44547	0.44547	6
DMU12	0.55744	0.23701	0.13212	0.13212	29
DMU13	0.47863	0.11407	0.0546	0.0546	44

DMU14	0.4529	0.94846	0.42956	0.42956	7
DMU15	0.57793	0.3803	0.21978	0.21978	17
DMU16	0.54512	0.24152	0.13166	0.13166	30
DMU17	0.23269	0.55404	0.12892	0.12892	31
DMU18	0.62846	0.5374	0.33774	0.33774	11
DMU19	0.46595	0.38535	0.17955	0.17955	21
DMU20	0.58587	0.34998	0.20504	0.20504	18
DMU21	0.55706	0.43226	0.2408	0.2408	16
DMU22	0.89288	0.34566	0.30863	0.30863	13
DMU23	0.30634	0.38342	0.11745	0.11745	32
DMU24	0.65279	0.27322	0.17836	0.17836	22
DMU25	0.43649	0.4248	0.18542	0.18542	19
DMU26	0.33266	0.1943	0.06464	0.06464	41
DMU27	0.36976	0.17352	0.06416	0.06416	42
DMU28	0.36609	0.19801	0.07249	0.07249	40
DMU29	0.93774	0.33472	0.31388	0.31388	12
DMU30	0.49768	0.36196	0.18014	0.18014	20
DMU31	0.80399	0.50104	0.40283	0.40283	9
DMU32	0.60421	0.14244	0.08606	0.08606	37
DMU33	0.70432	0.08111	0.05713	0.05713	43
DMU34	0.72717	0.10852	0.07891	0.07891	39
DMU35	0.556	0.25282	0.14057	0.14057	27
DMU36	0.55398	0.26301	0.1457	0.1457	26
DMU37	0.88793	0.55418	0.49208	0.49208	5
DMU38	0.68286	0.23949	0.16354	0.16354	24
DMU39	0.43718	0.37622	0.16447	0.16447	23
DMU40	0.78634	0.13786	0.10841	0.10841	33
DMU41	0.28671	0.18007	0.05163	0.05163	45
DMU42	1	1	1	1.4483	2
DMU43	0.54085	0.17891	0.09677	0.09677	35
DMU44	0.94824	0.72702	0.68939	0.68939	4
DMU45	1	1	1	2.67248	1

According to the conducted two-stage evaluation, it was determined that at the first stage of the screening, two branches among the 45 ones had been evaluated as efficient based on the primary indexes, and the other branches were not efficient due to weakness in the input and output indexes and only two branches among 45 ones were efficient

at the second stage in the final evaluation which was discussed. According to the analysis performed on the 45 branches of the bank under study, it was determined that the two-stage analysis provides a more comprehensive evaluation than the one-stage method respecting the number of evaluation indexes, and the branches number 42 and number 45 are efficiently proportional to the performed evaluation. The total efficiency evaluation showed that two branches among 45 ones enjoy total efficiency.

Efficiency correlation evaluation with input and output indexes at each stage

A) Efficiency Correlation evaluation of input indexes efficiency with total efficiency

According to the conducted investigation, all the input indexes of the first stage should use the Spearman's coefficient non-parametric test to check the correlation, and each one of the indexes is discussed below:

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \tag{8}$$

In equation (8), (x,y) is the independent variable data pair, and (x̄,ȳ) is the mean of the data pair. Therefore, based on the above formula, Spearman's coefficient is described in Table 3.

Table 3. Assessment of the evaluation indexes of the first stage-input indexes.

Indexes	The number of DMU	Spearman coefficient	α	P-value
Bank location (degree of importance from the experts' opinion based on a 5-option Likert scale)	45	-0.364	0.05	0.014
Branch line's employees	45	0.094	0.05	0.540
Total cost	45	0.314	0.05	0.035

The obtained result shows a correlation between the bank location and total cost; the bank location has an inverse correlation, and the total cost has a direct correlation. On the other hand, there is no correlation since the p-value of the number of employees is greater than 0.05 (Table 4).

Table 4. Assessment of the evaluation indexes of the first stage-output indexes.

Indexes	The number of DMU	Spearman coefficient	α	P-value
sources	45	0.42	0.05	0.005
Consumption	45	0.302	0.05	0.044
Service-providing	45	0.707	0.05	0.000
Valuable papers	45	0.320	0.05	0.032

The obtained result shows a correlation between all the output indexes, and according to this evaluation, this correlation is very strong in the bank branches' services (Table 5).

Table 5. Assessment of the evaluation indexes' correlation of the first stage-input indexes.

Indexes	The number of DMU	Spearman coefficient	α	p-value
Total cost	45	0.314	0.05	0.035
Service-providing	45	0.707	0.05	0.000
Expenditure	45	0.302	0.05	0.044
Sources	45	0.412	0.05	0.005
General employees	45	0.299	0.05	0.046
Facilities and equipment	45	0.289	0.05	0.055

The obtained result shows a correlation between all the input indicators of the second stage except the facilities and equipment index, whose p-value is more than 0.05 (Table 6).

Table 6. Assessment of the evaluation indexes' correlation of the second stage-output indexes.

Indexes	The number of DMU	Spearman coefficient	α	p-value
Total costs	45	0.289	0.05	0.005

The obtained results show that there is a correlation between all the output indexes of the second stage

5. CONCLUSION AND FUTURE SUGGESTIONS

In Iran, banks operate in the form of the financial markets beside other sectors as intermediary institutions, including capital markets, and collect people's small and aimless capital and use them to provide facilities and make investments on a macro level. But, this part of the financial markets is not paid enough attention due to the lack of acculturation to enter the capital market, the lack of individuals' risk-taking, and the lack of capital market growth in Iran. Therefore, Iran's economy is significantly bank-oriented, which means any weakness and shortcomings in the operation of Iran's banks may have a negative impact on the country's economic conditions. In this regard, the efficiency topic is a vital issue in Iran's banking sector, and dealing with its effectiveness is a strategic step in economic development in the country. Also, following the sanction removing the JCPOA (Joint Comprehensive Plan of Action), Iran's banks should have the necessary efficiency to be present in the world arena. Therefore, improving the efficiency of the banking sector can play a significant role in the country's financial system development and economic growth. For this purpose, the impact of some important factors on the efficiency of Iran's banking sector should be investigated. In this research, important factors such as capital, branch location, asset value income, etc., were used to identify the factors affecting the efficiency of banks. Therefore, examining the factors affecting the productivity and efficiency of the banking sector introduced in the country's stock market is necessary. Many studies have been done in this field due to the importance of the topic in Iran. The efficiency measurement method is as sensitive as the sample size in all these studies. A two-step method has been used to solve this problem. Therefore, the efficiency of the branches was evaluated in two stages, respecting the identification of 45 selected bank branches according to the developed data envelopment analysis model, and then, all the branches were ranked using Anderson's model. According to the research results, developing and evaluating the data envelopment analysis model presented in fuzzy mode is suggested to develop future research.

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