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A Novel Approach to Evaluating Bank Branch Performance: Integrating Financial Ratios and Data Envelopment Analysis (DEA)

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Abstract

The banking system has a direct and reciprocal relationship with economic growth; thus, improving the efficiency of banks contributes significantly to sustainable economic development. Efficiency can be defined in various ways—for instance, a fully efficient organization utilizes 100% of its potential. Efficiency is typically assessed from technical, allocative, and economic perspectives, using both basic and advanced methods. In manufacturing firms, final outputs are usually tangible and well-defined. However, in the banking sector, outputs are less concrete and depend on how a bank's role is conceptualized. Two major perspectives define the function of banks: First, as financial intermediaries where inputs include labor, capital, and deposits, and outputs comprise loans and other income-generating assets; and second, as service providers—where inputs remain labor and capital, but outputs include deposits, loans, and other financial services. This study evaluates the efficiency of bank branches using two distinct approaches: Financial ratios and Data Envelopment Analysis (DEA). The findings highlight and compare the strengths and limitations of each method, providing a comprehensive view of branch performance.

Keywords: Data envelopment analysis, Efficiency evaluation, Input-output identification, Bank branches, Financial ratios.

1 | Introduction

One of the institutions that plays a crucial role in the optimal allocation of a society's economic resources is banks and financial and credit institutions. Banks carry out a wide range of activities in society.

These activities range from granting loans and credit to managing securities, to facilitating the transfer of funds and foreign exchange transactions. Performing these operations efficiently and effectively not only

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fosters macroeconomic growth and prosperity but also leads to increased profitability and improved performance at the micro-level. Enhancing bank profitability and operational efficiency requires evaluating and analyzing operational efficiency. On one hand, assessing the efficiency of bank operations can ensure the achievement of goals and identification of weaknesses. On the other hand, it can help establish reward and punishment systems to improve performance (Efficiency) [1].

One of the methods for assessing efficiency and performance is the financial ratios analysis method. In this method, financial ratios are created using the inputs and outputs of the entity, where the output is in the numerator and the input is in the denominator, and the result indicates the efficiency of the economic unit. Financial ratios, which are extracted from the financial statements published by the accounting system, are used to analyze the financial status of an entity and compare it with other entities. The calculated financial ratios are then compared to ratios deemed appropriate for the entity under consideration (Performance benchmark) [2]. Financial ratios can be used to assess the overall financial accuracy of a bank or branch and evaluate the operational efficiency of its management [3].

However, this method also has drawbacks and limitations. According to Barnes [4], there are methodological issues that highlight the weaknesses of financial ratio analysis. The main drawback is that one or a few ratios cannot provide sufficient information about the various aspects of performance. For instance, a bank that is not well-managed in the short term might still perform well in the long term [5]. Another issue with financial ratio analysis concerns the choice of benchmark or comparison criterion, where single or multiple ratios are used to analyze performance [6]. Generally, using performance ratios is not feasible when evaluating the performance of entities with various outputs (Such as service or commercial institutions) alongside multiple inputs.

These limitations have led researchers to explore new methods for measuring efficiency in the banking industry. Initially, they adopted parametric programming methods based on the production function. In this context, economists developed frontier methods for assessing efficiency. Frontier production functions, a subset of parametric methods, are categorized based on the criteria used for comparing entities. Since frontier functions are never practically observable, Farrell [7] proposed estimating the frontier function using sample data (Entities).

The Data Envelopment Analysis (DEA) method, introduced by Charnes, Cooper, and Rhodes (CCR) [8], expanded upon Farrell's method by incorporating the characteristics of production processes involving multiple inputs and outputs into economic literature. This method, which is widely recognized as a standard approach to measuring efficiency, provides information not only on efficiency but also on the returns to scale for each entity. With the advancement and refinement of this method, DEA has become a highly active research area in efficiency measurement and has gained widespread acceptance among global researchers [9].

DEA is particularly useful for evaluating the performance of public and non-profit organizations where price (Monetary) data is usually unavailable or unreliable. DEA, which employs linear programming techniques, is one of the non-parametric methods for estimating iso-production functions. Technical efficiency only requires data on inputs and outputs, while economic efficiency also requires information on prices. Most non-parametric frontier models (Such as the Charnes, Cooper, and Rhodes model from 1978 [8]) and several early parametric frontier models (Such as the Aigner, Lovell, and Schmidt model from 1977 [10]) emphasized technical efficiency. DEA is specifically designed to measure technical efficiency in the public and non-profit sectors, where real price data is either unavailable or unreliable and assumptions of cost minimization or profit maximization may not hold [8].

2 | Theoretical Foundations

This article first identifies the financial ratios that play a key role in measuring the efficiency of bank branches in Iran. To identify these ratios, banking literature and texts were reviewed, and a list of ratios effective in evaluating branch efficiency was extracted. The most essential items studied and analyzed in this research are as follows:

2.1 | Inputs (Input Variables)

Bank data essentially refers to the resources available to the bank, which are used to carry out its operations. These resources are categorized into four groups: Human resources, payable interest, non-performing loans, and the number of branches [11].

2.2 | Outputs (Output Variables)

Outputs are the results of banking operations, achieved through the utilization of resources. These outputs are categorized into four groups: Primary deposits, other deposits, loans, customer satisfaction level, and cost. The following criteria form the basis for selecting outputs [12]:

I. They must be the final product of the organization.

II. They must be measurable.

III. They should reflect the organization’s objectives and intentions as closely as possible.

IV. They should not create undesirable managerial incentives.

2.3 | Financial Ratios

The Basel Committee on Banking Supervision (Basle Committee on Banking Regulations and Supervisory Practices) is composed of representatives from central banks and supervisory authorities of the Group of Ten (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom, the United States, and Luxembourg). The committee meets at the Bank for International Settlements (BIS) in Basel, Switzerland [13].

As part of its supervisory responsibilities, the committee mandates that member country banks calculate key financial ratios under the Capital Adequacy, Asset Quality, Management, Earnings, and Liquidity (CAMEL) framework to evaluate performance. These ratios assess capital adequacy, asset quality, management quality, income efficiency, and prudent asset-liability management to ensure liquidity and mitigate risks from interest rate fluctuations [14], [15].

While these ratios apply to banks as independent units with financial statements such as profit and loss, balance sheets, and equity, some of them are not applicable at the branch level. For example, the capital adequacy ratio cannot be calculated for individual branches. Therefore, in this study, only those ratios that are computable at the branch level have been selected and analyzed.

As mentioned earlier, in the financial ratios method, a ratio is formed by using the firm's inputs and outputs, with outputs in the numerator and inputs in the denominator, and the resulting ratio indicates the firm's efficiency. However, if there are multiple heterogeneous and non-aggregable inputs and outputs, the issue of various ratios arises for measuring efficiency. Measuring efficiency is the issue because for each ratio, there may be a different entity considered efficient, making it difficult to identify the best-performing one definitively. *Table 1* presents the list of ratios and their classification into different groups [16].

Table 1. List of ratios, their classification, and coding method.

Code	Ratios
S1	Simple liquidity (Liquidity group)
S2	Return on assets ratio (Profitability group)
S3	Difference between interest paid and received
S4	Guaranteed
S5	Ratio of other operating income to total assets
S6	Asset turnover ratio
S7	Ratio of outstanding receivables to total facilities
S8	Employee efficiency group

Table 1. Continued.

Code	Ratios
S9	Per capita profit ratio
S10	Employee efficiency ratio
S11	Ratio of number of wire transfers and types of bank checks to number of employees
S12	Ratio of number of wire transfers and types of bank checks to average assets
S13	Ratio of commission income to total income
S14	Ratio of commission income to number of wire transfers and types of bank checks

2.4 | Research Hypothesis

The financial ratios that influence the measurement of bank branch efficiency are presented in the form of the following main hypothesis:
"Main hypothesis: Financial ratios have equal importance in evaluating the efficiency of bank branches."
This main hypothesis includes 13 sub-hypotheses, each corresponding to one of the financial ratios. The list of these hypotheses is presented in *Table 1*.

3 | Research Methodology

The significance level of each financial ratio affecting the measurement of bank branch efficiency was determined using a survey method and through a questionnaire. The questionnaire was distributed in two stages, and consensus on the variables was achieved among experts from Bank Sepah.

To identify the key ratios for measuring bank branch efficiency using the financial ratios method, a comprehensive list of ratios was initially selected based on specialized literature and subjected to a preliminary review. Subsequently, in order to assess the validity of these ratios under Iranian environmental conditions, feedback from senior managers of Bank Sepah was collected via a questionnaire.

After identifying the essential ratios, their weight of importance was determined using the Analytic Hierarchy Process (AHP) in the next stage.

3.1 | Statistical Population and Sample

The statistical population of this research consists of experts (Managers, specialists, and branch heads) of Bank Sepah. Based on the list provided by the Department of Regional Affairs, Branches, and the Research Department of Bank Sepah, 84 individuals were randomly selected as the statistical sample.

In the first stage, 65 questionnaires were received, of which 57 were deemed valid. *Table 2* presents the number of questionnaires distributed, responded to, and validated in the first and second stages.

3.2 | Demographic Characteristics of Respondents

General information about the respondents—extracted from the first part of the questionnaire—is categorized by position, educational degree, academic field, and professional experience. Key highlights of the general information are summarized in *Tables 3* and *4*.

Table 2. Number of two-stage questionnaires.

Type	Delphi Phase 1	Delphi Phase 2
Total questionnaires distributed	84	57
Responded questionnaires	65	49
Acceptable questionnaires	57	40

Table 3. Classification of respondents by position in two stages.

Position	Step 1 Number	First stage Percentage	Step 2 Number	Second Stage Percentage
Branch manager	39	68	23	58
Banking expert	12	21	12	30
Academic	4	7	4	10
Other	2	4	1	3
Total	57	100	40	100

Table 4. Classification of respondents by work experience in two stages.

Experience	Step 1 Number	First stage Percentage	Step 2 Number	Second Stage Percentage
Less than 5 years	1	2	1	2.5
From 5 to 10 years	3	5	3	7.5
From 11 to 15 years	8	14	7	17.5
More than 15 years	45	79	29	72.5
Total	57	100	40	100

3.3 | Validity and Reliability of the Questionnaire

To assess the reliability of the measurement tool (The questionnaire), this study employed scientific methods and techniques to examine two aspects of reliability: The consistency of measurement results across all items, and the stability of responses given to each individual item [17]. To determine the consistency of measurement results across all items, Cronbach's alpha was used for both the first and second stage questionnaires. The values of Cronbach's alpha, presented in *Table 5*, indicate that both questionnaires in this study exhibit acceptable reliability. To assess the stability of responses, the test-retest method was employed. In this regard, questions 3s and 8s, which were phrased differently but measured the same concept, were tested. The correlation coefficient for the corresponding "ratios" was 0.86, indicating a strong relationship. Additionally, the repeated ratios were tested using the binomial test, and the ratios 3s and 8s were confirmed to yield similar results.

Table 5. Determining the stability of measurement results in two stages.

Questionnaire	Number of Completed Questionnaires	Number of Questions	Cronbach's Alpha Coefficient
First stage	57	41	0.9159
Second stage	40	12	0.8037

3.4 | Hypothesis Testing

The results of the expert survey indicated that out of 13 financial ratios, four ratios were confirmed and nine were rejected, as shown in *Table 7*. Among the 13 ratios submitted for evaluation, four were identified as significant. To address the issue of multiple (Or numerous) ratios, the ratios must be aggregated so that a single value can represent efficiency. Therefore, to measure the efficiency of branches, the AHP was used to determine the weight (Importance coefficient) of each ratio. The importance coefficient of each ratio was calculated using the weighted average of the opinions from 15 consistent questionnaires, and the results are shown in *Table 6*. Additionally, the consistency ratio of the weighted average was 0.012. Experience has shown that if the consistency ratio is less than 0.10, the comparisons can be considered acceptable; otherwise, the comparisons should be repeated [18]. The proposed formula for measuring efficiency using financial ratios is as follows:

$$E_j = S_2 \times A_j + S_3 \times B_j + S_4 \times C_j + S_7 \times D_j. \quad (1)$$

Each ratio value for a branch denoted by letters A to D is calculated individually for each branch and entered into the formula. The importance coefficient of each ratio denoted by S is the same for all branches, and its values are provided in *Table 6*. Therefore, the formula can be written as:

$$E_j = 0.36 \times A_j + 0.23 \times B_j + 0.22 \times C_j + 0.19 \times D_j \ . \quad (2)$$

The Efficiency value (E) of each branch is obtained as a single figure by calculating the sum of the products of each ratio value (A to D) and its corresponding importance coefficient.

Table 6. Importance coefficient of each ratio using the AHP method.

Code	Ratios	Weighted Average
S2	Return on assets ratio	36%
S3	Difference between interest paid and received	23%
S4	Net profit ratio resulting from the difference in guaranteed interest rates	22%
S7	Ratio of fueled claims to total facilities	19%

4 | Data Envelopment Analysis

DEA is a linear programming method used to evaluate the efficiency of Decision-Making Units (DMUs) that operate with multiple inputs and outputs. The popularity of DEA compared to other methods stems from its ability to handle complex and often unknown relationships between multiple inputs and outputs, many of which are typically non-measurable. Efficiency evaluation through DEA has even led to the identification of inefficiencies in highly profitable firms companies that were previously considered benchmarks due to their profitability orientation. The general assumption in unit evaluation is that reducing inputs and increasing outputs leads to improved performance and greater efficiency, and all DEA models are based on this premise. DEA constructs an efficiency frontier using linear programming based on the input and output data of organizations and production units regarded as DMU. This frontier is constructed through successive linear programming steps. The degree of inefficiency of each DMU is, in essence, the distance of that unit from the efficiency frontier. In fact, assessing the efficiency of economic units has long been one of the most critical concerns in academic and managerial circles. Finding optimal solutions requires that managers and planners be equipped with appropriate evaluation and organizational tools. Charnes et al. [8] were the first to introduce a set of linear programming problems in 1978 to formulate the measurement of Farrell's technical efficiency index [7]. Their approach to efficiency evaluation became known as DEA. They introduced the first foundational model in DEA for measuring relative efficiency under the assumption of constant returns to scale, which they called the CCR model. Later, Banker et al. [19] extended the CCR model to accommodate variable returns to scale, introducing what is known as the BCC model. These two models (CCR and BCC) are considered the core and fundamental models in the DEA methodology [19]. In this method, units that lie on the efficiency frontier are deemed efficient units, while those that fall below the frontier are considered inefficient units.

4.1 | Basic Models of DEA

4.1.1 | CCR model

This model for measuring the efficiency of DMUs was introduced in 1978 by Charnes et al. [8]. The CCR model is examined in two forms:

I. CCR model with input nature: In *Model (3)*, the maximum input reduction is considered, assuming that DMU_p, under evaluation $p \in \{1,2, \ \ldots . n\}$, we have:

$$
\begin{aligned}
&\min_{S.t.} \theta \\
&\sum_{j=1}^{n} \lambda_j X_j \le \theta X_p, \\
&\sum_{j=1}^{n} \lambda_j X_j \le \theta X_p, \\
&\lambda_j \ge 0 \ , \ j = 1,2,\dots,n, \\
&\theta_{free}.
\end{aligned} \tag{3}
$$

In the optimal solution of the above model, if $\theta^* < 1$ then DMU p is inefficient, and if $\theta^* = 1$ it means that DMU p lies on the efficiency frontier and is efficient. The presented model is the envelopment form of the input-oriented CCR model. The dual of this model, known as the multiplier form, is presented in *Model (4)*.

$$
\begin{aligned}
&\max_{S.t.} \ \theta = UY_p, \\
&VX_p = 1, \\
&UY_j - VX_j \le 0 \quad j = 1,2,\dots, n, \\
&V \ge 0 \ , \quad U \ge 0.
\end{aligned} \tag{4}
$$

II. Output-oriented CCR model: In this model, the objective is to achieve the maximum possible increase in outputs. This model is presented in *Eq. (5)*.

$$
\begin{aligned}
&\max_{S.t.} \ \varphi_p, \\
&\sum_{j=1}^{n} \lambda_j X_j \le X_p, \\
&\sum_{j=1}^{n} \lambda_j Y_j \ge \varphi_p Y_p, \\
&\lambda_j \ge 0 \ , \ j = 1,2,\dots,n.
\end{aligned} \tag{5}
$$

In this model $\varphi_p = 1$, and $\lambda_j = 0$ and $\lambda_p = 1$ constitute a feasible solution. The above model is referred to as the envelopment form of the output-oriented CCR model. The multiplier form (Dual form) of the output-oriented CCR model is presented in *Model (6)*.

$$
\begin{aligned}
&\min_{S.t.} \ VX_p, \\
&UY_p = 1, \\
&UY_j - VX_j \ge 0 \quad j = 1,2,\dots, n, \\
&V \ge 0 \ , \quad U \ge 0.
\end{aligned} \tag{6}
$$

4.2 | Case Study

This example uses a real dataset from the Iranian banking industry to calculate efficiency using two methods: Financial ratios and DEA. The dataset comprises 36 banks with four inputs and five outputs, as shown in *Table 7*, with the input and output sets detailed in *Table 8*.

Table 7. Initial input and output data.

Inputs	Outputs
Interest payable	Total of four main deposits
Personnel	Other deposits
Non-performing loans	Loan granted
Number of branches	Satisfaction rate
	Cost

Table 8. Input and output set.

DMU_j	Input 1	Input 2	Input 3	Input 4	Output 1	Output 2	Output 3	Output 4	Output 5
1	9613.37	37.65	84759	1	3329887	297174	1853365	125740.3	6957.33
2	15532.94	180.59	61958	31	1032209	47213	603535	101954.3	1933.16
3	126080.5	484.13	276331	52	5612194	1029508	4915352	458971.4	11675.5
4	96673.59	524.54	203463	53	5055067	751987	4451299	1170466	4165.45
5	36009.31	355.1	83063	48	2352032	587191	2658741	301877.3	9823.13
6	126996.1	281.7	514770	36	4086246	572085	7229407	1651658	9597.59
7	148663.8	407.83	99109	46	5963247	350118	4310802	306716.7	7749.21
8	84976.67	475.01	312233	49	4856452	1619029	15404277	556634.3	16761.5
9	19974.47	264.11	100550	46	1086599	130035	1036956	141755.8	2037.73
10	8610.57	151.45	29690	34	561205	17191	160966	25769.91	760.47
11	91420.46	761.88	56339	141	3668523	207215	1233188	212174.7	3878.89
12	31671.65	553.37	63011	98	1395097	61601	885057	144835.5	1542.24
13	1033.36	28.67	2294	6	111405	20620	51623	11145.17	330.08
14	10211.72	181.94	19690	45	531252	23326	264577	32961.04	823.72
15	12098.68	187.25	22074	48	545604	50998	388262	50012.51	1090.69
16	69644.45	707.47	264966	144	2816198	228157	1845860	396005.1	4499.13
17	5904.57	136.97	26135	33	375766	21099	316199	66704.81	1800.7
18	7579.14	48.78	21150	14	235131	6612	275886	47256.77	744.73
19	29790.28	435.85	115841	89	1883405	114512	1110637	214657.2	5921.28
20	5715.69	105.05	21621	28	409514	23472	408952	73139.83	1119.49
21	8842.88	153.35	24258	34	489644	41759	459395	62111	1933.55
22	8538.53	147.42	41735	30	425121	18253	423538	104604.2	959.48
23	17588.21	431.41	61578	97	1048564	34059	742439	114658	2599.56
24	27252.82	466.47	93704	80	1518312	125579	1246112	185292.4	4478.81
25	5096.07	138.57	22765	30	365397	13324	283338	53301.03	1296.07
26	2896.07	66.45	20220	18	177291	9544	296160	69356.54	786.42
27	5350.62	127.44	23367	27	397498	7176	380091	83297.25	1050.32
28	8779.18	114.59	11205	26	497640	21464	368410	78644.5	1625.97
29	2956.67	166.52	33618	36	437192	23814	280821	52314.21	1939.15
30	11379.31	256.65	120629	57	1052715	60694	761748	158207.3	2653.74
31	14582.94	307.67	44077	69	824138	35747	765280	173461.9	2323.59
32	54564.38	1103.05	373142	195	2883002	162295	2476927	349511.8	6817.82
33	12683.31	180.44	19440	38	697401	18101	1163837	194130.7	2608.02
34	8621.95	154.08	19242	35	432605	22450	254390	60728.98	1368.19
35	11987.37	218.49	38563	43	717260	35503	598293	98287.35	1038.17
36	28061.32	534.96	10288	93	1455764	71063	1231176	198089.6	3013.47

To calculate *Eq. (2)*, we need: D_j , C_j, B_j , A_j is the asset return ratio A_j for each DMU, which is given in *Table 9* along with the efficiency results of the two methods as a percentage. B_j The difference between the interest paid and received ratio S_2 is for each DMU, which was taken into account considering the rate of 18% for loans and 15% for one-year deposits. $B_j = 1.2$ is the amount of guaranteed interest or interest payable for each DMU, which is actually the first input for each DMU, which was used as a percentage in *Eq. (2)*. D_j is the ratio of fueled claims to total facilities S_7 for each DMU, which was taken into account considering the bank's announcement $D_j = 0.52$.

Table 9. Efficiency obtained from the two methods of financial ratios and DEA.

DMU_j	A_j	Efficiency from Financial Ratios	Efficiency from DEA
1	170	1	1
2	66.4	0.431	0.45
3	44.5	0.69	0.76
4	52.2	0.630	1.00
5	65.3	0.494	1.00
6	32.1	0.619	1.00
7	40.1	0.633	1.00
8	57.1	0.616	1.00
9	54.4	0.377	0.49
10	65.1	0.399	0.41
11	40.1	0.545	1.00
12	44	0.358	0.45
13	107.8	0.611	1.00
14	52	0.33	0.49
15	45	0.297	0.49
16	40.4	0.469	0.38
17	63.6	0.38	0.76
18	31	0.202	0.58
19	63.2	0.461	0.57
20	71.6	0.423	0.75
21	55.3	0.342	0.68
22	49.7	0.519	0.67
23	59.6	0.394	0.41
24	55.7	0.406	0.55
25	71.7	0.42	0.72
26	61.2	0.355	1.00
27	74.2	0.439	0.91
28	56.6	0.347	1.00
29	147.9	0.845	1.00
30	92.5	0.526	0.66
31	56.5	0.368	0.72
32	52.8	0.483	0.34
33	54.9	0.35	1.00
34	50.1	0.312	0.57
35	59.8	0.375	0.57
36	51.8	0.391	1.00

As we know, the efficiency results obtained from the DEA method are as follows. To make the results of the financial ratios method easily comparable with DEA model results, the results of this method are normalised so that they are all between zero and one. These results are shown in the third column of *Table 9*. By comparing the results of the two methods, we can see that the DMUs are uniquely ranked in the financial ratios method, with no two units having exactly the same efficiency score. In contrast, in the DEA method, many units have similar rankings, and ranking requires the use of developed DEA models. However, the AHP method is used in financial ratios, which is based on managers' opinions and can influence decision-making towards personal interests to some extent, whereas DEA results are based solely on the comparison of similar observed units.

5 | Conclusion

One of the most significant outcomes of this research is the development of a formula to measure efficiency using the financial ratios method. This formula is derived from the AHP and can be used to express the efficiency of each unit as a specific number. When we calculated the efficiency of 36 bank branches using the financial ratios method and DEA, we found that the financial ratios method produced more discriminatory results. However, accounting ratios are also criticised as criteria for evaluating performance. For example, accounting standards are considered inflexible. Business conditions are constantly changing and evolving, whereas accounting standards remain more or less constant. Problems with the financial ratios method led us to seek an alternative method of measuring efficiency in the banking industry. DEA is a parametric programming method that is suitable for obtaining the efficiency of DMUs from banks' tables. Although there are many advantages to calculating efficiency with DEA, including the absence of managers' personal opinions in the calculation, the discriminatory power of the financial ratio method was far greater than that of DEA.

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