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Determination of the Malmquist Productivity Index for Assessing the Performance of Mellat Bank Branches in Lorestan Province, Iran

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Abstract

Measuring the productivity of banks, accompanied by analyzing and comparing their performance, have important roles in improving their productivity and efficiency so that they make up the backbone of the plans of banks. Initially, the Malmquist Productivity Index (MPI), one of the indicators of productivity measurement, is introduced. Hence, the paper describes how to obtain this index using the Data Envelopment Analysis (DEA). Then, the performance of Mellat Bank branches in Lorestan province is evaluated using the MPI to identify the efficient branches and the critical indicators of each branch, in order to increase their productivity.

Keywords: Data Envelopment Analysis, Productivity, Efficiency, Malmquist Productivity Indicator

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1. Introduction

The performance of a company in converting input to output can be scaled in different ways. One way to measure this performance is through the ratio of productivity. Productivity is a relative relationship to highlight different performances through comparisons. Thus, the productivity of one company in a specific year can be measured through its productivity during another year, or the productivity of another company in the same year.

The study of the trend of productivity with the context of parametric methods was first conducted by the seminal research of Robert Solow in 1957 [1]. In his extensive studies on the productivity growth of the US, he attributed the growth to advances in technology and technical knowledge. After Solow, other researchers took steps to theoretically develop his method and eliminate its problems and practical limitations. In 1982, by removing the condition of efficiency for the units under study, Nishimizu and Page proved that the effective factor in productivity growth is affected by three components: modification of efficiency, use of more input resources, and technological changes [2]. Although the mentioned parametric methods could theoretically justify all economic events, due to the use of parametric context and production function, they faced computational and practical complexity. The difficulties with the use of parametric methods -despite their theoretical strength- have led researchers such as Caves, Chirstensen, and Dievert to use nonparametric methods[3]. They introduced the MPI as a growth indicator in production theory in 1982[4]. Introducing the DEA as a generalization of the non-parametric Farrell method [5] by Charnes, Cooper, and Rhodes in 1978 led the methods for calculating the productivity growth toward applying the DEA[6]. It is noteworthy that many efforts have been made in the DEA, some of them listed by the work of Tavares (1978–2001) [7], wherein more than 3000 publications over the mentioned periods were recorded. Assaf, Matousak, and Tsionas (2013) evaluated the productivity of Turkish banks using the Bayesian stochastic frontier approach and found that banks with lower efficiency have higher shares of overdue receivables [8]. Fuji, Managi, and Matousek (2014) investigated the growth of efficiency and productivity in the Indian banking industry using Russell directional distance functions. Their study established that foreign banks are more efficient than domestic banks [9]. Liu et al. (2015), taking fixed assets and equipment as inputs, and loans and deposits as outputs, adopted the DEA to study the performance of the Taiwanese banks [10]. The DEA has also been widely applied in the US and other industrialized countries in Europe and Asia.

The astonishing development of this method enables it to describe a wide range of scientific theoretical and applied matters, including the study of economic and managerial concepts. In this paper, we address one of the topics of the DEA entitled “total productivity”, which determines the MPI in evaluating the performance of Mellat Bank branches in Lorestan province during the Iranian fiscal years 2014–15 and 2015–16.

This section presents the required concepts, definitions, tools, and methods;

Data Envelopment Analysis

Definition: Let there are n decision-making units $(DMU_j;\ j=1,...,n)$ where each of them has m inputs and s outputs. We represent the input and output vectors with $x_j=(x_{ij};\ i=1,...,m)$ and $y_j=(y_{rj};r=1,...,s)$, respectively. We assume that the elements of both vectors are positive: $x_{ij}>0$ and $y_{rj}>0$ for any $i=1,...,m$ and $r=1,...,s$. (the rest of the definition!)

2. CCR Output-Oriented Model

In an output-oriented model, an inefficient unit is made efficient through the proportional increase in its outputs, while the inputs' proportions remain unchanged. Accordingly, this section aims to get the point $(x_k, \phi y_k)$ on the efficient frontier through the output extension. To get this objective, we consider the following problem:

$$
\begin{aligned}
&\max \quad \phi \\
&s.t. \quad x_{ik} \geq \sum_{j=1}^{n} \lambda_j x_{ij} \quad , \quad i=1,\ldots,m \\
&\sum_{j=1}^{n} \lambda_j y_{rj} \geq \phi y_{rk} \quad , r=1,\ldots,s \\
&\lambda_j \geq 0 \quad , \qquad j=1,2,\ldots,n
\end{aligned}
\tag{1}
$$

Model (1) is called the closed form of the CCR output-oriented model. Taking the intended maximum value equal to ϕ^*, if $\phi^* > 1$ then DMU_k is non-efficient while in case of $\phi^* = 1$, DMU_k is relatively efficient. Malmquist Productivity Index Assume over the period t, the input and output vectors are in order $x^t = (x_1^t, \ldots, x_m^t)$ and $y^t = (y_1^t, \ldots, y_s^t)$. The technology of the period t can be defined as the following set of ordered pairs:

$S^t = \{ \ (x^t, y^t) \mid \ x^t \text{ can generate } y^t \ \}$

Now, having the set of possibilities, we can define the function of output distance between (x^t, y^t) and technology of the period t for the k-th unit (DMU_k) as

$$
\begin{aligned}
D_k^t(x^t, y^t) &= \inf\{\theta : (x^t, \frac{y^t}{\theta}) \in S^t\} \\
&= [\sup\{\theta : (x^t, \theta y^t) \in S^t\}]^{-1}
\end{aligned}
$$

Here, if the unit under consideration has m inputs and s outputs, and there are totally n DMUs, the function above is computable as follows:

$$
\begin{aligned}
&[D_k^t(x^t, y^t)]^{-1} = \max \quad \sigma \\
&s.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij}^t \leq x_{ik}^t \qquad i=1,\ldots,m \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^t \geq \sigma y_{rk}^t \quad r=1,\ldots,s \\
&\lambda_j \geq 0 \quad j=1,2,\ldots,n
\end{aligned}
\tag{2}
$$

Replacing t with $t+1$, the value $D_o^{t+1}(x^{t+1}, y^{t+1})$ can be obtained. To calculate the value $D_o^{t+1}(x^t, y^t)$, we can use the following planning problem:

$$
\begin{aligned}
&[D_o^{t+1}(x^t, y^t)]^{-1} = \max \quad \sigma \\
&s.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \leq x_{io}^t \quad , \quad i=1,\ldots,m \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \geq \sigma y_{ro}^t , \quad r=1,\ldots,s \\
&\lambda_j \geq 0 \quad j=1,2,\ldots,n
\end{aligned}
\tag{3}
$$

Similarly, the value of $D_o^t(x^{t+1}, y^{t+1})$ can be calculated;

$$
\begin{aligned}
&[D_o^t(x^{t+1}, y^{t+1})]^{-1} = \max \quad \sigma \\
&s.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij}^t \leq x_{io}^{t+1} \quad , \quad i=1,\ldots,m \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^t \geq \sigma y_{ro}^{t+1} , \ r=1,\ldots,s \\
&\lambda_j \geq 0 \quad j=1,2,\ldots,n
\end{aligned}
\tag{4}
$$

Therefore, the total change of roductivity from period t to period $t+1$ equals to

$$
M_o^{t,t+1}(x^t, y^t, x^{t+1}, y^{t+1}) = \left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)} . \frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \right)^{\frac{1}{2}}
$$

Now, there are three phases for the alculated variable:

1. $M_o^{t,t+1} > 1$ shows the increasing in productivity as a progress.
2. $M_o^{t,t+1} = 1$ indicates no change in productivity.
3. $M_o^{t,t+1} < 1$ conveys a drop in productivity as a retrogression.

3. Numerical examples

Perhaps the most important step in employing the DEA technique to measure the relative efficiency of any company or institution is to select appropriate and homogeneous inputs and outputs, and to do this, all aspects, outputs, and inputs must be considered. However, according to the interviews conducted with bank managers, considering the viewpoints of the experts, the literature of the research, and employing the hierarchical analysis method, for evaluating the performance of Mellat Bank branches in Lorestan province, inputs and outputs have been selected as follows:

INPUTS	**OUTPUTS**
Number of employees	Average claims
Branch space	Performance
Average cost	

Due to the confidentiality of information, in the present report, we avoid referring to the name of the branches, and the information on the branches is provided under codes of 1 to 18. After modeling this data, the amount of change in productivity from the years 2015–16 to 2016–17 can be calculated. To calculate the changes in the MPI and thus to examine productivity changes in such issues, specialized software for operations research (or particularly, for the DEA) is needed. In this paper, the calculations of the underlying models are done by GAMS software.

As seen in Table 1, data (inputs and outputs) are provided for eighteen branches of Mellat Bank in Lorestan Province. These data were completely real, and after modeling them, the following results were obtained and collected in a tabular format.

Table 1. The calculated MPIs over 2015–16 and 2016–17, and their changes for the eighteen branches of Mellat Bank in Lorestan Iran

Branch (DMU)	MPI (2015–16)	Rank of MPI (2015–16)	MPI (2016–17)	Rank of MPI (2016–17)	Change of MPI	Rank of change
1	0.8.2	10	0.751	11	-0.051	12
2	0.771	12	0.810	9	0.039	6
3	0.813	9	0.520	18	-0.293	18
4	0.683	14	0.681	13	-0.002	7
5	0.992	4	1.059	2	0.067	4
6	1.007	3	1.002	4	-0.005	8
7	0.792	11	0.663	14	-0.129	16
8	0.668	16	0.610	17	-0.058	14
9	0.990	5	0.984	6	-0.006	9
10	1.112	1	1.865	1	0.753	1
11	0.842	7	0.623	15	-0.219	17
12	0.662	17	0.621	16	-0.041	11
13	0.950	6	0.882	8	-0.068	15
14	1.055	2	1.003	3	-0.052	13
15	0.660	18	0.991	5	0.331	2
16	0.670	15	0.726	12	0.056	5
17	0.731	13	0.941	7	0.210	3
18	0.820	8	0.810	9	-0.010	10

It is well knowing that productivity is an indicator that makes sense over time periods. Therefore, these data are studied over two separate periods of 2015–16 and 2016–17 through the columns 2–3 and 4–5 in Table 1, respectively. The changes in amount of productivity between these two periods are presented on columns 6–7 of Table 1 as well.
According to calculated MPIs reported in Table 1, the highest amount of productivity belongs to Unit 10 (10th branch). This standing indicates that the mentioned branch has relatively – compared to the other seventeen branches- made the best use of the facilities and achieved the best result. After Unit 10, Unit 14 placed second in terms of the minimum use of inputs to obtain the maximum output among the Mellat Bank branches in Lorestan province. It is noticeable that if the obtained amount of productivity exceeds one, equals one, or be lower than one, it, respectively, indicates the productivity growth, no change, or a decrease in productivity during the period. With this explanation, it is observable that other than the 10th and 14th branches, the 3rd one has had productivity growth over 2015–16, and the other branches of the province have had a decline in productivity. At the bottom of the ranking of the 3rd column of Table, the twelfth and fifteenth branches are suffering from some significant problems in the optimal use of resources and are far from achieving the desired result.
Similarly, for 2016–17, the MPIs of the branches are reported in the fifth column of Table 1. Observably, in this time interval, with MPI 1.865, the 10th unit still has the highest amount of productivity changes. During this period, the second place belongs to the 5th branch, which has a value of 1.051, with only 0.05 units more than the cut-off point. Units 14 and 6 are the other branches with MPIs greater than 1. At the bottom of the standing of the period 2016–17, the 3rd and 12th branches have the weakest performances, with the productivity values of 0.520 and 0.621, respectively.
The increments of the MPIs between the two periods are listed in the sixth column of Table 1, which underlies the ranks of the seventh column.
Through the amount of progress or decline in the MPIs over the two periods under discussion, it is inferable that the 10th unit, going from 1.112 to 1.865, experienced the greatest rise in MPI, with 0.753 unit's growth. Hence, the 10th branch has operated more productively in the period of 2016–17 than in 2015–16. With around one-third and one-fifth of rising, the 15th and 17th branches have the second and third most significant growth between the two periods, respectively. Units 2, 5, and 16 have experienced some slight rises as well. Also, the weakest performances, in terms of the last column of Table 1, belong to branches 3, 11, and 7, which drop, respectively, 0.293, 0.219, and 0.129 units.

4. Conclusion

Productivity is one of the principal responsibilities of management. By increasing productivity, several other main goals of the managers are achieved simultaneously. Consequently, managers of branches of banks should know the factors that improve the productivity of their branches. In this regard, this paper aimed at assessment of the performance of Mellat Bank branches in Lorestan province, Iran, founded on the Malmquist Productivity Index (MPI) calculated using the Data Envelopment Analysis (DEA). This study demonstrates that the 10th branch is the most productive among the eighteen branches under study, and -due to applying full capacity based on the indicators of "average claims" and "performance"- can be a reference unit for the others in the province. Therefore, as a way to improve productivity, the other managers of the Mellat Bank branches in the province can consider the managers of the 10^{th} branch as a reference. The average receivables index was also introduced as the most sensitive indicator. Another key point is to find the best criteria for budget allocation to different branches of Mellat Bank in Lorestan province. The productivity assessment with the new approach, due to high accuracy and reliability, can be considered as a suitable performance criterion by policy-makers and planners. In particular, the government's approach to budget allocation is currently focused on performance-based operational budgeting. Additionally, the other branches can be directed towards efficiency and resource-saving through improving the quantity and quality of services, average claims, and continuous performance evaluation. In the end, this study, in addition to introducing performance models to the top managers of Mellat Bank branches, provided them with more accurate planning to develop service capacity and save resources.

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