Optimization
Iranian Journal of Optimization
Volume 10, Issue 2, 2018, 125-137
Research Paper
Online version is available on: www.ijo.iaurasht.ac.ir

Islamic Azad University
Rasht Branch
ISSN: 2588-5723
E-ISSN:2008-5427

The Application of Super Efficiency Techniques in Measuring the Efficiency of Bank Branches (Case study: Melli Bank of Guilan Province)

Mitra Safari[1], Mansoor Soofi[2*] and Mahdi Homayounfar[2]

[1] Master of Business Administration, Faculty of Management and Accounting, Rasht Branch, Islamic Azad University, Rasht, Iran
[2] Assistant Professor, Department of Industrial Management, Faculty of Management and Accounting, Rasht Branch, Islamic Azad University, Rasht, Iran

Received: 08 October 2017
Accepted: 20 November 2017

Abstract

In today's competitive world, many manufacturing and service firms, including banks, have been forced to use new managerial approaches and methods to assess organizational performance. The Data Envelopment Analysis (DEA) approach is one of these approaches, which has been used to evaluate the performance of organizations since 1978. The purpose of this research is to use the technology super-efficiency in measuring the efficiency of bank branches (the case of Melli Bank of Guilan Province). In this research, the input-oriented model of DEA in the form of constant return-to-scale and Anderson-Pearson (AP) super-efficiency have been employed to measure the efficiency of Class 1, 2 and 3 branches of Melli Bank in Guilan Province in 2015. In summary, the results showed that the average efficiency score of the surveyed branches was 0.75 in 2015. Golsar branch of Rasht was found to be the most efficient branch, and Kish Shahr Bandar was the most inefficient branch since its efficiency score of 0.8 was lower than the average of all branches. It was revealed that advertisement and marketing expenses were the most important cause of poor cost management in inefficient branches, and the inefficient branches were weakest in human resource training planning

Keywords:
Performance evaluation
Data Envelopment Analysis
Super Efficiency
banks

***Correspondence E_mail**: msoufi45@gmail.com

INTRODUCTION

Financial institutions play a crucial and decisive role in resource allocation, economic growth, and job creation. Effective financial firms are necessary to promote and support economic growth for any country (Roghanian et al., 2012). Banking industry is one of the most complex industries in the world, and it has a major contribution to the wealth of countries. In the UK, 25% of GDP is generated by financial services (Paradi et al., 2011).

The use of cloud services makes it possible to develop an ongoing relationship between both public and private sectors to serve the public. Cloud computing is attractive for business owners since they can begin to work with smaller business with fewer resources, and add to their capacity of resources as demand grows from users. This is attractive to users in the sense that, instead of spending high costs, they can exploit the calculation resources or the required software packages to use the services provided by suppliers and make a great saving in their costs (Sasikala, 2013). Because of the service nature of cloud computing, service providers need to have full knowledge of the state of their cloud computing system, and be able to evaluate its performance continuously, so that they can provide the appropriate response to the quality demand of users. There are challenges in evaluating the efficiency of cloud computing environment arising from the presence of various applied and service models for implementing resource allocation policies and timing algorithms. Examples include diversity of costs, the lack of reproduction of test results, and the mistrust of cloud service providers to vague assessments and trial-and-test method. We also need to provide solutions to simulate and evaluate the efficiency of cloud computing in order to ensure the quality of the service provided (Vecchiola et al., 2009). The current methods of evaluating and measuring banking units are empirical methods whose results in different banks are not the same due to lack of standardization. In addition, these methods have no regard for the efficiency of the units, and merely focus on the utilization of units. DEA is a scientific and non-parametric methodology for assessing the efficiency and inefficiency of decision-making units (DMUs). This methodology has abundant scientific applications in banks, hospitals, power plants, insurance, universities, etc. (Min et al., 2013). DEA is a comprehensive approach adopted to assess performance in the banking industry, and the popularity of this approach is mainly due to multiple inputs and outputs in this model and its suitability to investigate nonlinear relationships in analyses (Chang et al., 2011). This methodology is a nonparametric method that can simultaneously consider multiple variables as inputs and outputs (Bray et al., 2014). DEA models used to evaluate the performance of banks act as a black box. Performance is calculated in areas such as technical, cost, profitability, and productivity, with the assumption that inputs are consumed to produce outputs (Chan, 2006). Mathematically, DEA is a linear programming methodology that calculates the efficiency of a DMU based on the production area that is determined by all DMUs. Its main advantage is that we do not need to determine parametric specifications (e.g. production function) to estimate efficiency scores. (Siriopoulos & Tziogkidis, 2010).

A number of studies have focused on measuring the performance of organizations, especially banks, using DEA techniques, both in Iran and abroad. Isazadeh and Mazhari (2017) studied the effect of management efficiency on reducing costs after the banking consolidation in Iran. The results of the model estimation show that the hypothetical merger between the two banks causes a decrease in the cost due to management efficiency, but the removal of branches cannot reduce the cost of the merged bank. In other words, the merging of the two banks could reduce the costs of the merged bank through the transfer of managerial efficiency. Azar et al. (2014) measured the productivity of bank branches with the approach of network data envelopment analysis in a case study on one of the banks of Guilan Province. The conventional DEA models for performance assessment are based on black box approach in which it is assumed that inputs are converted to outputs in DMUs, regardless of the mediating process. The process of providing services in banks is composed of interactive and interdependent stages. This conjugation led to the design of this research using the network data envelope analysis approach, which is a model for measuring efficiency, effectiveness, and productivity in the banks. In this respect, personnel size and asset are used as the inputs, personnel expenses and administrative expenses are considered as the mediating variables, and total income and total saving are regarded as the outputs. Finally, the efficiency, effectiveness, and efficiency of branches of one of the banks of Guilan province are measured using the proposed model in different processes and at different levels. The interesting result of this research is that the most efficient branch is not necessarily the best branch in terms of prosperity. Portela and Thanassoulis (2010) examined 57 bank branches in Portugal in order to develop a benchmark for banks' productivity gains even with negative data. They used the DEA model with the number of employees and the amount of rent as input and the number of transactions, the number of customers, the volume of current accounts, the volume of other accounts, the volume of deposits, the volume of loans, and credits as output. Shahabinejad et al. (2015) measured the efficiency and compared productivity growth of Melli Bank branches in Kerman province using a comprehensive data analysis in 2010-2012. In order to achieve this purpose, various branches were classified according to the Bank's grading in four groups; the first group included grade 1 and grade 2 branches, group 2 included grade 3 branches, group 3 included grade 4 branches, and finally, group 4 consisted of grade 5 and grade 6 branches. Then, the efficiency and productivity growth of different branches were calculated within each group. The results showed that the average productivity growth for the years 1, 2, 3, and 4 was 1, 6, 9, 8, and 1, respectively. Also, the average rate of technical efficiency with the inferiority approach, and the assumption of variable returns to scale, in groups 1, 2, 3, and 4 were 87, 77, 99, and 91, respectively; that is, the modification of the management practices can reduce the level of utilization of the input. At the current level of branch outputs, the level of input use in the four groups was 1, 23, 13, and 9 percent, respectively. The results of the analysis of the return on the scale showed that in the four groups, 50, 63, 80 and 65 percent of the branches had an increasing return to scale, indicating that the majority of Melli Bank branches in Kerman province had to increase their production capacity to reduce their scale inefficiencies. Chang et al. (2012) calculated the productivity index for bank inputs using the comprehensive data analysis method. In this study, inputs were composed of fixed assets, capital, and employees, and outputs included loans, and other assets were used to calculate the productivity index. The results showed that, during the period under consideration, technical advances have reduced the total productivity growth of the factors of production and efficiency.

Kao and Liu (2009) used the DEA method to measure the performance of commercial banks in Taiwan. In this research, they examined the method of measuring the efficiency of each bank by computer simulation. The number of personnel, physical capital, purchased funds, deposits, and short-term and long-term loans constituted the inputs and output of the DEA technique in this research. Wang et al. (2014) used the two-stage DEA model to assess the efficiency of Chinese commercial banks. The most important findings of their research were: 1) two-stage DEA model is much more effective than conventional models of DEA, and 2) the overall efficiency of the Chinese banking system has improved during the research period due to reforms. Wanke et al. (2016) calculated the efficiency of Chinese commercial banks by the super-efficiency data envelopment analysis. In this study, inputs included asset-wide, fixed-term, labor, and deposit data, and outputs were composed of income, non-core earnings, and loans. The results showed that the efficiency of the banking system was increased over the research period. Chen et al. (2013) used a fuzzy DEA model based on auxiliary variables (fuzzy SBM) to evaluate the performance of Taiwan banks. Their presented model provides performance values in varying degrees, which are in line with the specifications of risk prediction, and the achievements of Taiwan's banking management under market risk. Saboonchi and Mousavi (2016) focused on performance analysis and prioritization of sports and youth departments of Lorestan province using DEA. The BCC model of this research was output-oriented assuming variable return to scale. In the research process, reference sets were calculated. In this study, after the efficiency scores of efficient and inefficient offices were calculated and the type of return to scale was determined for them, the reference sets were specified. Then, the offices were ranked using DEA and TOPSIS ranking methods separately. To incorporate the four ranks obtained from four scopes, ranks were averaged. The highest score of the performance of the sports and youth departments was related to the field of championship sport, and the lowest average performance score was related to the areas of civil and sport. Moshkinru et al. (2015) examined efficiency by relying on the DEA technique and ranked bank branches using LJK super-model. Twenty-three bank branches formed the statistical research population. Bank inputs included employees, computer terminals, and area, outbound deposits, and loans. It was revealed that AP model had some unsolved problems that are not seen in LJK model. Also, LJK model can assess all DMUs in terms of both efficiency and super-efficiency. Therefore, we use super-efficiency techniques to assess the relative efficiency of class 1, 2 and 3 branches of Melli Bank and to rank them using DEA. We, indeed, attempt to answer the question as to how much the efficiency scores of class 1, 2 and 3 branches of Melli Bank are in Guilan Province using AP super-efficiency model.

According to the explanation of the problem, the present study aims to apply super-efficiency techniques to evaluate relative efficiency of Melli Bank branches in Guilan province, rank them, and present an improved methodology to prioritize bank branches. Similarly, we have tried to present a linear combination of efficient branches that managers can achieve by taking advantage of the efficiency with the target pattern. Finally, the key indicators (inputs and outputs) were determined to evaluate the efficiency of the Melli Bank branches.

DATA ENVELOPMENT ANALYSIS

The methods used in this research are as follows:

Super-efficiency model for DEA

After classifying the performance of the groups, it is necessary to determine which units outperform the others. In other words, they should be rated. There are a plethora of ideas as to how to rate DMUs, for instance Anderson-Peterson super-efficiency model and cross-efficiency model. DEA super-efficiency model was proposed by Anderson and Peterson in 1993 in an attempt to improve the DEA techniques. In addition to estimating the efficiency scores for DMUs and listing the efficient and inefficient DMUs as is done by traditional CCR models proposed by Copper in 1976, the super-efficiency model can calculate scores for DMUs that are considered to be efficient due to the fact that their efficiency score is 1. These scores can be larger than one (Lee & Zhu, 2012). Cloud computing models can calculate performance scores for each unit, and simultaneously rank them (Avkiran, 2011).

Input oriented super-efficiency envelopment model under constant return to scale

Given that the form is of the intrinsic nature of the model, it is considered to be of super-efficient models. First we describe the input oriented and the super-efficient model, and then we introduce the cover form of the super-efficiency model under the efficiency to the constant return to scale of the input oriented. In general, DEA models are divided into two groups, the input-oriented, and the output-oriented.

Charnes et al. (1978) have defined the efficiency, according to these two views, as follows:

• In input-oriented model, an inefficient unit, if it does not exist, can reduce each input, without increasing other inputs, or reduce each output.

• In an output-oriented model, an inefficient unit, if it does not exist, can increase each output without increasing the input, or reduce one output. After the efficiency of DMUs is assessed, it is important to identify the units that have outperformed the others. In other words, we should deal with the issue of rating. There are a plethora of ideas as to how to rate DMUs, for instance Anderson-Peterson super-efficiency model and cross-efficiency model. DEA super-efficiency model was proposed by Anderson and Peterson in 1993 in an attempt to improve the DEA techniques. In addition to estimating the efficiency scores for DMUs and listing the efficient and inefficient DMUs as is done by traditional CCR models proposed by Copper in 1976, the super-efficiency model can calculate scores for DMUs that are considered to be efficient due to the fact that their efficiency score is 1.. These scores can be larger than one (Lee & Zhu, 2012). In fact, cloud-efficient models can calculate performance scores for each unit, and rate DMUs simultaneously (Bray et al., 2014)

One of its model types is the super-efficiency model under the constant return to scale with input-oriented nature. As described in the previous chapters, the concept of the efficiency of the constant return to scale means that the change in the input value leads to the similar change in output (Mehregan, 2008).

The multiplier of this model is as follows:

$$\begin{aligned} &\text{Max } Z_0 = \textstyle\sum_{r=1}^{s} u_r Y_{r0} \\ &\text{St:} \\ &\sum_{i=1}^{m} v_i x_{i0} = 1 \\ &\textstyle\sum_{i}^{m} v_i x_{ij} \leq 0 \quad - \quad \sum_{r=1}^{s} u_r y_{rj} \\ &U_r, v_i \geq 0 \\ &(i=1,2,\ldots,m), \quad (r=1,2,\ldots,s), \quad (j=1,2,\ldots,n) \end{aligned} \tag{1}$$

Eq.1 represents a multiple-form of the AP super-efficiency model under the constant return to scale inputs

A limitation should be written for each unit. Thus, a linear programming model will be obtained with the number of restrictions being greater than the number of variables, and since the number of operations in a simplex solution depends on the number of restrictions, not variables, therefore, solving the secondary problem of the above model requires less number of operations, the result of which is called the cover model, which, with slight variations on the multiplicative model, will cover the model as follows.

$$\begin{aligned} &\text{Min } Y_0 = \\ &\text{St:} \\ &\textstyle\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r_0} \qquad (r=1,2,\ldots,n) \\ &\textstyle\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{i0} \qquad (i=1,2,\ldots,m) \\ &\lambda_j \geq \theta \qquad \Theta\text{free} \qquad (j=1,2,\ldots,n) \end{aligned} \tag{2}$$

Eq. 2 shows the cover form of the AP super-efficiency model under the efficiency to the constant return to scale of the input-oriented

The value obtained for θ specifies the efficiency level for firm *r*, and it should be solved *n* times to evaluate the efficiency of *n* companies.

where:

n is the number of Class 1, 2, and 3 branches in Guilan province,

m is the number of inputs, and *s* is the number of outputs.

y_{ri} is the output of all *n* units, y_{ro} is the output of under the unit examination.

In the same way, there is an input for all *n* units, and one input is under the unit review.

λ_i represents the weight of reference sets, for inefficient branches.

A decision-making unit is effective when:

1. θ.=1
2. $s_r^+ = s_i^- = 0$

As stated above, input-driven models are models that reduce inputs by keeping outputs constant. Given that the selected model is the input-oriented, then inefficient units should reduce their inputs by taking reference units by keeping outputs constant, assuming that they get the same output. Technical efficiency has originated from the concepts of economy and show the different aspects of economic efficiency. This efficiency is affected by the managerial performance, and the scale of that unit of the firm (Joo et al., 2011). Technical efficiency reflects the ability of a firm to obtain maximum output from inputs (Mehregan, 2008). In this study, to calculate the technical efficiency of the cover model, the super-efficiency model under the constant-scale efficiency inbound nature was used. Since most optimization models of research in operation, including linear and nonlinear models, presently exploit software packages to facilitate the analyses, it is unavoidable to use computer to enhance the speed and accuracy of calculations when algorithms of optimization models are run. The specialized software packages related to each science are divided into two categories: low-level and high-level packages. Low-level software packages are designed for non-professional users. They are simple, but lack programming capability. In contrast, there is the possibility of programming for users in high-level software. TORA, DS, WINQSB, etc., are examples of low-level software, and GAMS, DEA SOLVER, LINGO, etc. are examples of high-level software packages (Toloo and joshangahi, 2010). In this research, GAMS was used to solve data envelopment analysis models.

Data Envelopment Analysis Output and Input

DEA ratios, in fact, is a mathematical programming method for measuring decision-makers based on a set of observations, thus acting on the empirical estimate of the efficiency boundary. This method obtains a boundary function, in which all data is covered, and for that reason, it is called "data envelopment analysis" or "comprehensive analysis." Because the method is based on a set of optimization problems, and there is no parameter for its analysis, it is a non-parametric method (Charnes et al., 1978). This model, developed by Charens et al. (1978), added that the use of mathematical programming, Farl's, was a nonparametric perspective, which was introduced in 1957, to evaluate the efficiency of decision-making units with two inputs and one. It came to be known as the CCR model, with a constant-scale efficiency, which has the ability to measure performance with multiple inputs, and multiple outputs. In 1984, Bunker, Charles, and Cooper proposed a new model, called BCC, with a variable return to scale, as modified by the CCR model (Mehregan, 2008). In this research, according to paradigm presented by Khaki et al. (2012), Kádárová (2015), and Avkiran (2011), the input and output variables were first selected for DEA technique, and then, the efficiencies of Melli Bank branches in Guilan Province were calculated by DEA super-efficiency models.. The proposed research model is as follows:

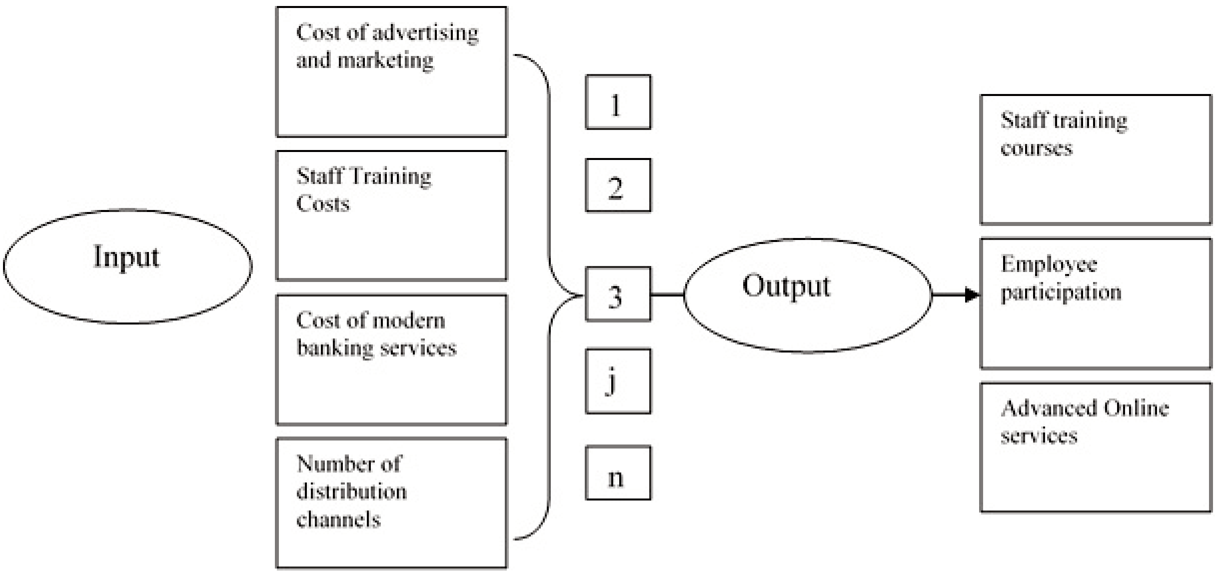

Fig.1. Proposed model of research, derived from Khaki et al. (2012)'s model (Khaki et al., 2012)

The statistical population of this research included all branches of Melli in Guilan Province amounting to 129 branches. In this research, a systematic elimination method was used to select the statistical sample. For this purpose, those branches satisfying the following requirements were sampled:

- The selection of class 1, 2 and 3 branches of Melli Bank across Guilan Province
- Exclusion of branches having missing data

Since the efficiencies of Melli Bank branches in Guilan Province are estimated by DEA super-efficiency technique and concurrently, they are rated to use the efficient branches as a model, the number of the studied branches should be, at least, equal to

The number of units evaluated$\geq 3\times(m+s)$

where m is the number of inputs, and *s* is the number of outputs. Failure to apply the above relationship causes a large number of units to be located on the efficient boundary. In other words, their efficiency score becomes (1). Therefore, DMUs' discrimination capability is lost (Mehregan, 2008) The present study consists of four inputs and three outputs, and in total, at least 21 DMUs are available. Thirty active class 1, 2, and 3 branches were selected as the sample.

Inputs:

(1) Advertising and marketing costs: those costs that are spent over a year to attract customers to the banks;

(2) The number of distribution channels: a

structural distribution channel from within-company organizational units, and outsourced brokers, wholesalers, and retailers that market goods or services. This included the number of covered covers (outside the branch), the number of sales points (POS) covered, the number of ATMs per branch;

(3) The cost of modern banking services: the costs incurred by the Internet Banking System, Telephone Banking System, Mobile, PayPal, Kiosk, Fax, POS, Foreign Exchange Services

(4) Training Costs: The costs incurred to the banks to train staff, over a year.

Outputs:

(1) Staff training courses: Total long-term and short-term training hours for employees of each branch;

(2) Employee participation: the number of recommendations by the employees in each branch to improve the respective branch;

(3) Online Services: Internet, mobile phone, telephone bank, fax, advanced services such as currency services for a year, including (number of international cards issued, swift number issued and entered, number of foreign currency dealers, number of domestic and foreign currency transfers, transfers/encrypted faxes, domestic and foreign currency numbers, wire transfers/encrypted faxes)

RESEARCH RESULTS

According to research methodology, the technical efficiency of the Melli Bank branches of Guilan Province was measured by DEA super-efficiency input-oriented model under constant return to scale. After the efficient branches were determined and they were ranked, it was possible for the inefficient branches to use the efficient branches as model and find out their weaknesses.

Efficiency is merely a comparison between the expected resources that is consumed to achieve specific goals and activities, and resources consumed; therefore, efficiency is the performance criterion of an organization's system on the amount of resources (inputs); in other words, efficiency refers to the amount of resources used to produce a certain level of (Rakhshan & Alirezai, 2014).

The efficiency of unit j= $\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} V_i X_{ij}}$

X_{ij}: i input value, for unit j i=1,2,3,…,m

y_{rj}: The output r, for unit j (r = 1,2,3, ..., s)

U_r: weighted output r (outlet price r)

V_i: weighted to input i (input cost i)

This research is an applied research in terms of purpose, and is a field research based on the implementation. Also, there is a descriptive survey in terms of method and information gathering. According to research methodology, the technical efficiency of the Melli Bank branches of Guilan Province was measured by DEA super-efficiency input-oriented model under constant return to scale. After the efficient branches were determined and they were ranked, it was possible for the inefficient branches to use the efficient branches as model and find out their weaknesses.

FINDINGS

Descriptive statistics of DEA variables

In order to evaluate the general characteristics of the variables, estimate the model, and analyze them accurately, descriptive statistics were applied to the variables. Table 1 presents the statistics and descriptions of the data collected from class 1, 2, and 3 branches of Melli Bank in Guilan Province in 2015.

Measuring the performance of the model

As stated, the efficiency of class 1, 2 and 3 branches of Melli Bank in Guilan Province were measured by input-oriented AP DEA super-efficiency model under constant return to scale. Data collected in 2015 were used to define the decision variables, and the parameters of the DEA mathematical model. To measure the efficiency of class 1, 2 and 3 branches of Melli Bank in Guilan Province, data obtained from these models were inputted into the GAMS Software. Tables 2 and 3 show the scores for performance, the reference units for the inefficient branches, the surplus inputs, and the lack of output.

Table 1: Descriptive statistics of DEA variables

Variable	Type	mean	Maximum	minimum
Advertising and marketing costs (x_1)	277.21	419.54	696.75	Input
Staff cost (x_2)	10	15	12.5	Input
Cost of new banking services (x_3)	277.6	419.16	696.14	Input
Number of distribution channels (x_4)	277.4	419.11	848.7	Input
Staff training course (y_1)	182	502	342	Output
Staff participation (y_2)	50	115	82.5	Output
Online and advanced services (y_3)	514.4	21.12	8.862	Output

Table 2: Efficiency score from DEA for 2015, and introduction Reference units

Melli Bank (3) branches at the level of Guilan Province	Reference units	Performance Score ()
Khamam (2)	1	2.07
Lahijan (1)	2	3.33
Shahid Ansari Blvd (2)	(2) 0.9, (5) 0.16, (16) 0.19	0.77
Iraq Rasht Bridge (2)	(24) 0.09, (16) 0.29, (5) 0.2, (1) 0.1	0.92
Chaboksar (2)	, (6) 0.71, (5) 0.2, (2) 0.01, (24) 0.11, (10) 0.2	1.38
Golsar Rasht (1)	6	9.89
Aalam al-Hoda street Rasht (2)	(6) 0.42, (1) 0.84	0.40
Takht-e Tahestan Rasht (2)	(17) 0.05, (10) 0.58, (6) 0.08	0.53
Sadi Rasht Street (2)	, (10) 0.44, (6) 0.02, (5) 0.14, (24) 0.16	0.43
Property of Rasht (3)	10	2.79
Razi Rasht (3)	, (6) 0.03, (2) 10.2, (1) 0.01, (24) 0.11	0.48
Municipality of Rasht (3)	12	1.59
Ghadir Rasht (3)	, (2) 0.61, (12) 1.12, (1) 0.09	0.78
Breaking down (3)	, (16) 0.4, (5) 0.47, (2) 0.02, (24) 40.2	0.82
Mohtasham Rasht (3)	, (16) 0.48, (12) 0.02, (1) 0.13	1.17
Kochsefhan (3)	, (10) 0.12, (1) 0.21	1.33
Garlic worktops (3)	, (16) 0.18, (10) 0.54, (6) 0.02, (17) 0.76	0.98
Ghazi (3)	, (5) 0.06, (2) 0.02, (24), 0.04, (16) 0.14, (10) 0.39	0.50
Bandar Anzali Golestan (3)	, (24) 0.17, (2) 0.32, (1) 0.25	0.73
Customs Clearance (3)	(16) 0.22, (2) 0.02, (1) 0.27, (24) 0.05	0.58
Asalem (3)	(10) 0.18, (2) 0.07, (1) 0.45, (16) 0.18, (24), 0.05	0.68
Pearce (3)	, (24) 0.01, (10) 0.23, (6) 0.04	0.83
Kishakhsh Harbor (3)	(6) 0.06, (5) 0.024, (2) 0.08, (24) 0.19, (10) 0.06	0.8
Imam Khomeini Lahijan Street (3)	24	4.54
Rahimabad (3)	(6) 0.07, (2) 0.04, (1) 0.09	0.90
Clutch (3)	(6) 0.07, (5) 0.06, (2) 0.17, (10) 0.35	0.39
Rudbar (3)	(10) 0.7, (1) 0.65	0.68
Louchan (3)	(16) 0.29, (2) 0.15, (1) 0.03, (24) 0.21	0.54
Manjil (3)	(16) 0.21, (10) 0.28, (5) 0.14, (24) 0.08	0.25
Shaft	(10) 0.48, (6) 0.09	0.63

The GAMS software can calculate surplus amounts of resource use, and lack of output for inefficient DMUs, as shown in Table 3.

Table 3: Excessive use of resources, and lack of productivity, for each unit

Row	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.27	0.00	0.00	0.00	0.04	0.00	0.00
4	0.00	0.05	0.00	0.04	0.00	0.00	0.00
5	0.06	0.00	0.00	0.00	0.67	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.10	0.00	0.3	0.00	0.00	0.00	0.00
8	0.00	0.00	0.11	0.01	0.04	0.31	0.00
9	0.09	0.00	0.00	0.00	0.00	0.14	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.05	0.00	0.00	0.00	0.00	0.05
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.12	0.19	0.00	0.11	0.19	0.00
14	0.54	0.00	0.00	0.00	0.05	0.00	0.00
15	0.00	0.00	0.11	0.00	0.00	0.16	0.00
16	0.00	0.00	0.07	0.00	0.00	0.00	0.02
17	0.87	0.00	1.16	0.00	0.00	0.00	0.02
18	0.00	0.01	0.07	0.00	0.01	0.00	0.00
19	0.09	0.00	0.00	0.00	0.13	0.00	0.03
20	0.00	0.00	0.00	0.00	0.13	0.00	0.00
21	0.00	0.00	0.00	0.00	0.13	0.00	0.00
22	0.00	0.00	0.61	0.61	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.07	0.00
26	0.01	0.04	0.00	0.00	0.00	0.03	0.00
27	0.01	0.02	0.02	0.00	0.15	0.00	0.07
28	0.07	0.03	0.03	0.00	0.04	0.00	0.00
29	0.01	0.00	0.00	0.00	0.02	0.00	0.00
30	0.00	0.10	0.10	0.00	0.00	0.00	0.04

Analyzing technical performance results

In this section to analyze the results of Tables 2 and 3, we analyze the multiplier efficiency of the class 1, 2, and 3 branches of Melli Bank in Guilan Province in different years:

• Kalachay Branch (DMU 26, Class 3 Branch)

Using the data pertaining to the bank branches, the efficiency scores of 26 DMUs estimated by input-oriented DEA super-efficiency model under constant return to scale were used to derive their technical efficiency score for 2015.

It should be noted that ε = 0.00001 was used for zero values to avoid the computational errors in the GAMS software. Referring to Table 2, the technical efficiency score of Kalachay Branch in 2015 was 0.39. By calculating the second phase of the super-efficiency model AP, it will be possible to analyze the causes of the inefficiency of the Kalachay Branch in 2015. According to Table 3, the surplus amount is 0.01 for the expense of advertising and marketing, 0.2 for staff training, 0.2 for the cost of new banking services at the entrance, and 0.2 for lack of employee participation in the outflows, constituting the factors responsible for inefficiency of Kalachay Branch, as compared to other branches of Guilan Province in 2015. In other words, the branch has not been successful in obtaining the maximum capacity to provide banking services from a certain amount of its inputs (including cost variables) and shortage of employees' involvement in the output, in providing banking services, compared to other branches. In fact, the lack of cost management in the advertising sector, the modern banking services, staff training, and the lack of sufficient programs to attract employee participation cause shortages in attracting the number of customers. As described in the preceding parts, one of the features of the DEA model is the determination of reference units for inefficient units. According to Table 2, the class 1 branches of Lahijan, class 3 branches of Chaboksar, class 1 Golsar Branch of Rasht, and class 3 Daraei Branch of Rasht were selected as the efficient models for Kalachai Branch. The weight λ assigned to each reference class 1, 2 and 3 branch of Melli Bank in Guilan province is as per Table 2, showing the contribution of each reference branch in the assessment of inefficient Kalachai branch. For example, λ (shadow price) of 0.17 in 2015 for reference Lahijan Branch, 0.06 for reference Chaboksar Branch, 0.07 for reference Golsar Branch and 0.35 for reference Daraei Branch of Rasht show that the similarity of inefficient Kalachai Branch for using these reference branches as mode is 0.35, 0.07, 0.06 and 0.17, respectively. Finally, a virtual branch is derived as below:

$$0.17\begin{bmatrix}0.2\\0.85\\0.12\\0.2\end{bmatrix}+0.06\begin{bmatrix}0.3\\0.03\\0.12\\0.3\end{bmatrix}+0.07\begin{bmatrix}0.43\\0.04\\0.1\\0.43\end{bmatrix}+0.35\begin{bmatrix}0.1\\0.021\\0.4\\0.1\end{bmatrix}=\begin{bmatrix}0.04\\0.007\\0.14\\0.04\end{bmatrix}$$

As you can see, the entries of the virtual unit are equal to $\begin{bmatrix}0.04\\0.007\\0.14\\0.04\end{bmatrix}$ while the actual input of the Kalachay Branch is $\begin{bmatrix}0.3\\0.4\\0.45\\0.3\end{bmatrix}$. According to Table 3, excess resource utilization in resources, due to the lack of management in the expenditure section of the advertising and marketing sector, and employee training have led to the calculation of efficiency points for this branch.

• Lahijan Branch (DMU 2, Class 1 Branch)

Using the data of appendices in Chapter 3, the overall form of input-oriented AP-DEA super-efficiency model under constant return to scale used to derive the technical efficiency score for this branch for 2015 is as follows. It should be noted that to avoid computational errors in the GAMS software, ε=0.00001 was used for zero values.

The efficiency score of Lahijan Branch in 2015 was found to be 3.33. The score of ≥1 in super-efficiency models implies that the DMU is efficiency. So, Lahijan Branch was found to be efficient in terms of banking industry as compared to other class 1, 2 and 3 branches of Guilan Province. As can be seen in Table 3, the surplus input use by this branch is zero. That is, the branch has been successful in deriving the maximum amount of banking services from a certain amount of inputs compared to other branches, and because of the lack of surplus and deficits, this unit is considered to be strong. For other branches, analyses are also the same. It is necessary to explain that the units that have surplus resources or lack of resources are, in fact, poorly efficient[1].

As is evident in Table 4, Golsar branch of Rasht (the first branch) was found to be the superefficient branch among other branches.

[1] If $\theta=1$, and S_i^- , s_r^+ then the decision making unit is weak.

Table 4: Ranking of Effective Units

Unit	Branch name	Super Efficiency score
6	Golsar Rasht (1)	9.89
24	Imam Khomeini street of Lahijan (3)	4.54
2	Lahijan (2)	3.33
10	Rasht Agency of Finance (3)	2.79
1	Khamam (2)	2.07
12	Municipality of Rasht (3)	1.59
5	Chaboksar (2)	1.38
17	Koochesfahan (3)	1.33
15	Mohtasham Rasht (3)	1.17

CONCLUSION AND RECOMMENDATIONS

DEA measures the performance of the DMUs by integrating the indices and the multiple dimensions, weighting them, and simultaneously considering several effective variables. This method assesses the efficiency of the branches and organization in utilizing the resources and finds out the best branches to set target for inefficient branches. According to Table 2, the efficiency was estimated for 30 class 1, 2, and 3 branches of Melli Bank in Guilan Province in 2015. The most efficient branches in 2015 were Khomam (class 2), Lahijan (class 1), Chaboksar (class 2), Golsar of Rasht (class 1), Daraei of Rasht (class 3), Shahrdari of Rasht (class 3), Mohtasham of Rasht (class 3), Kuchesfahan (class 3), and Imam Khomeini Street of Lahijan (class 3). In general, the average efficiency score was 0.75 for these branches in 2015. The efficient DMUs are usually rated by two methods. One is Anderson-Peterson method that was presented by Anderson and Peterson in 1993. The method ranks the efficient DMUs by changing the measurement boundary. DEA super-efficiency models were developed to improve DEA techniques. These models combine AP and DEA, allowing the calculation of efficiency score for different DMUs and concurrently, their rating. In this study, we aimed to simultaneously measure the efficiency of 30 branches of Melli Bank in Guilan Province and rank them based on the AP capture form of the super-efficiency model according to the constant return to scale of input-oriented. According to the results, the DMUs were ranked as below:

Golsar Rasht, Imam Khomeini, Lahijan (3), Lahijan (2), Rasht Office of Finance (3), Khamam (2), Rasht City (3), Chaboksar (2), Koochesfahan (3), Mohtasham Rasht (3).

DEA technique can identify efficient DMUs and compare the model DMUs with other units. These DMUs are presented in Table 2 according to which DMU 2 (Lahijan) and DMU 6 (Golsar of Rasht) can be used as model branches. In addition to measuring efficiency, DEA models can specify excessive resource exploitation and output shortage. Also, the calculation of λ value shows the contribution of each model branch in the assessment of inefficient branches so that targets can be set to adjust the use of excessive resources and the compensation of output shortage of inefficient DMUs. Table 2 includes the model efficient branches for each inefficient branch. In summary, the average efficiency score in 2015 was 0.75. According to the results of input-oriented AP-DEA super-efficiency ranking under constant return to scale, the class-1 Golsar branch of Rash was the most efficient branch and the class-3 branch of Bandar-e Kiashahr was the most inefficient branch with efficiency score of 0.8. According to the calculation of surplus resource use and output shortage in Table 3, the most important factor in the mismanagement of inefficient branch costs is related to the cost of advertisement and marketing and the most critical weakness is related to personnel training planning. Finally, it should be noted that banking industry is one of the most strategic industries. It was found that for final decision-making, the opinions of experts should be collected about the appropriate allocation of resources. The results lead us to make recommendation such as providing facilities like purchase coupon to personnel, holding recreational trips like hiking to motivate the personnel, improving their job satisfaction, and using professional personnel to enhance the quality of informatics department as per standards. Also, along the results of DEA calculation, we can find out the factors that can improve the efficiency of bank branches in long run.

REFERENCES

Avkiran, N. K. (2011). Association of DEA super-efficiency estimates with financial ratios: Investigating the case for Chinese banks. *Omega, 39*(3), 323-334.

Azar, A., Zarei, M., Abadi, M., Moghbel baarz, A., & Khadivar, A. (2014) ."Bank Branch Efficiency Measurement with Network Data Envelopment Analysis (One of the Banks of Gilan Province)", *Quarterly Journal of Monetary-Bank Research , 20*, 285-305.

Bray, S., Caggiani, L., Dell'Orco, M., & Ottomanelli, M. (2014). Features selection based on fuzzy entropy for Data Envelopment Analysis applied to transport systems. *Transportation Research Procedia, 3*, 602-610.

Chan, V. L. (2006). Effects of deregulation on bank efficiency and productivity in Taiwan. *Academia*.

Chang, K. C., Lin, C. L., Cao, Y., & Lu, C. F. (2011). Evaluating branch efficiency of a Taiwanese bank using data envelopment analysis with an undesirable factor. *African Journal of Business Management, 5*(8), 3220.

Chang, T. P., Hu, J. L., Chou, R. Y., & Sun, L. (2012). The sources of bank productivity growth in China during 2002–2009: A disaggregation view. *Journal of Banking & Finance, 36*(7), 1997-2006.

Chen, Y. C., Chiu, Y. H., Huang, C. W., & Tu, C. H. (2013). "The analysis of bank business performance and market risk—Applying Fuzzy DEA". *Economic Modelling, 32*, 225-232.

Charnes , A., Cooper, W.W., Rhodes E., (1978). Measuring the efficiency of the decision making units, European Journal of Operational Research 2 (6) 429–444.

Cooper, L. M .Seiford, K. Tone,(2002)."Data Envelopment Analysis(a text with comprehensive models, applications, references and DEA-Solver software)", Kluwer Academic, Publishers, USA, Third Printing.

Isazadeh, S., & Mazhari, M. (2017). "The Effect of Management Efficiency on Reducing Costs after the Consolidation of Banks in Iran" *Journal of Applied Economic Studies, 6*(21), 173-187 .

Joo, S. J., Nixon, D., & Stoeberl, P. A. (2011). Benchmarking with data envelopment analysis: a return on asset perspective. Benchmarking: *An International Journal, 18*(4), 529-542.

Kao, C., & Liu, S. T. (2009). Stochastic data envelopment analysis in measuring the efficiency of Taiwan commercial banks. *European Journal of Operational Research, 196*(1), 312-322.

Khakia, A. R., Najafib, S. E. & Rashidia, S. (2012)."Improving efficiency of decision making units through BSC-DEA technique" *Management Science Letters 2*, 245–252.

Lee, H. S., & Zhu, J. (2012). Super-efficiency infeasibility and zero data in DEA. *European Journal of Operational Research, 216*(2), 429-433.

Mehregan, M.R. (2008)."Quantitative Models in Organizational Performance Evaluation: Data Envelopment Analysis",Tehran, *Tehran University Press, Faculty of Publications*.

Min, H., Min, H., Joo, S. J., & Kim, J. (2013). "Evaluating the financial performances of Korean luxury hotels using data envelopment analysis" *International Journal of quality & reliability management , 25*(4),74-86.

Moshkinroo, M., Mirzai, M., & Rezanejad, A. (2015)."Rating of Bank Branches Using Super Efficiency Models" May 31-May 1994, *Eighth International Conference of Iranian Operations Research Association,* Ferdowsi University of Mashhad, Mashhad, Iran, May 31, 2015.

Paradi, J. C., Rouatt, S., & Zhu, H. (2011). Two-stage evaluation of bank branch efficiency using data envelopment analysis. *Omega, 39*(1), 99-109.

Portela, M. C., & Thanassoulis, E. (2010). Malmquist-type indices in the presence of negative data: An application to bank branches. *Journal of banking & Finance, 34*(7), 1472-1483.

Rakhshan, S. A. & Alirezaei, M. R. (2014). "Ranking of decision-making units using a non-radial super Efficiency model", *Industrial Management Department of Tehran University of Management, Department of Engineering, Faculty of Management, Tehran University, Tehran, Iran, 6*(2), 136-101.

Roghanian, P., Rasli, A., & Gheysari, H. (2012). Productivity through effectiveness and efficiency in the banking industry. *Procedia-Social and Behav-*

ioral Sciences, 40, 550-556.

Saboonchi, R., & Mousavi, S. M. (2016). "Efficiency Analysis and Prioritization of Lorestan Province Sports and Youth Departments, Using Data Envelopment Analysis". *Contemporary Research in Sport Management, 6*(11).

Sasikala, P. (2013). Research challenges and potential green technological applications in cloud computing. *International Journal of Cloud Computing, 2*(1), 1-19.

Shahabinejad, V., Shahabinejad H., & Sistani Badui, Y. (2015). "Measuring Performance, and Comparing Growth Growth of Melli Bank Branches in Kerman Province, Using Inclusive Data Analysis". *Quarterly Journal of Financial and Economic Policies ,3*(12), 124- 105.

Siriopoulos, C., & Tziogkidis, P. (2010). How do Greek banking institutions react after significant events?—A DEA approach. *Omega, 38*(5), 294-308.

Toloo, M. & Joshaghani, S. (2010)."Users Guide to GAMS with DEA Models", Tehran, Academic Edition.

Vecchiola, C., Pandey, S., & Buyya, R. (2009). "High-performance cloud computing: A view of scientific applications". In *Pervasive Systems, Algorithms, and Networks (ISPAN), 2009 10th International Symposium* on (pp. 4-16). IEEE..

Wang, K., Huang, W., Wu, J., & Liu, Y. N. (2014). Efficiency measures of the Chinese commercial banking system using an additive two-stage DEA. *Omega, 44*, 5-20.

Wanke, P., Barros, C. P., & Emrouznejad, A. (2016). "Assessing productive efficiency of banks using integrated Fuzzy-DEA and bootstrapping: A case of Mozambican banks". *European Journal of Operational Research, 249*(1), 378-389.