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Original Research Article

Using Satisficing Game Theory for Performance Evaluation of Banks' Branches (Case Study in the Bank Mellat)

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Due to its role in the identification of inefficient branches and deciding the consistency of their activities, evaluating the performance of a bank's branches is one of the most important decisions in the field of development and regulation of branch network. In this paper, the satisfactory functions based on game theory strategies have been utilized in order to evaluate the individual and within-group performance of the bank's branches. The proposed approach is based on a cooperative game theory, and the number of players is equal to the number of units which must be evaluated. The satisficing equilibrium set includes the options which are qualified as "good enough" or the efficient units which are both individually and within-group efficient. By applying our analytical method to the bank Mellat case study, we have presented solutions to improve the efficiency of inefficient branches and the branches which are only individually or within-group efficient using sensitivity analysis techniques. Lastly, if efficiency improvement is not possible, we have suggested omitting the branch.

Keywords: Performance Evaluation, Individual and Within-Group Evaluation, Satisficing Game Theory, Cooperative Game Theory.
JEL Classification: C71, G14

1 Introduction

Due to the fact that bank's branches are the main point of bank activities, in terms of income, expenses and interaction with customers, having a network of efficient and effective branches has always been considered as one of the strategic and fundamental challenges of banks. Following the privatization of bank Mellat and fundamental changes in strategies of this bank during recent years, there is a need to review the structure and organization of branches and

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make the branch network agile. One of plausible the measures is in this regard is omitting inefficient branches so that the efficiency of the branch network increases through reducing inputs and releasing resources, including human resource, building and reduction of other costs while current outputs are maintained at the same level. Therefore, the first step is identifying these inefficient branches.

So far, decision making about omitting branch is either done reactively or based on suggestions from management of branches which is proposed normally based on limitations such as lack of human resources or just based on its financial outputs. Accordingly, accurate investigation in order to find and apply the appropriate method for branches' performance evaluation seems necessary.

Data envelopment analysis (DEA) is a well-known method used widely in the field of performance evaluation. Basis of DEA for performance evaluation is "relative superiority" (that means finding the best) and for this aim, each decision-making unit (DMU) is compared with the best manufacturer (possibly virtual). However, most often, the "good enough" options are sufficient for decision maker. Decision maker more likely tends to group units as "good enough" or "not good enough", instead of ranking units in comparison with each other (Martin & Ariel 1994). The satisficing functions have been used based on cooperation game theory strategies that realized this aim (Tchangani, 2006). Therefore, in this work, we have used satisficing functions to evaluate branches' individual and within-group performance. Here the number of players equals the number of DMUs and utility function of each player includes two sections of profit (outputs such as financial resources) and cost (inputs such as human resource), which are defined through using satisficing functions of the section, which include select-ability function (regarding outputs) and reject-ability function (regarding inputs). According to these satisficing functions, two individual and within-group satisficing sets are determined and the satisficing equilibrium set consists of "good enough" options, which are both individually and within-group efficient.

This article is organized as the following: in section "research background", some of performance evaluation methods and the weaknesses and strength of the DEA method have been stated. In section "the concepts of satisficing game theory", we briefly present satisficing game theory concepts related to this work. Section "practical application" states the effect of sensitivity analysis on the results of the suggested approach, and finally, in section "conclusions", the suggested approach has been used for performance evaluation of the selected samples.

2 Research Background

2.1 Performance Evaluation Methods

The first step toward identifying inefficient branches is an appropriate evaluation of branches performance. So far, various methods have been used for performance evaluation of bank branches (Paradi et al., 2013), including ratio analysis that calculates the ratio between two variables. Failure of this method in solving problems with multiple inputs and outputs and inability in determining the best units has turned it into an inefficient method. The regression method measures the effect of multiple independent variables on a dependent variable, but it is a parametric method that needs a general production model and is suitable just for problems with one input and multiple outputs or vice versa. The methodologies of frontier efficiency measure relative performance of production units based on distance from the boundary of "best practice"; whether being parametric, such as the Stochastic Frontier Approach (SFA) and Distribution Free Approach (DFA), or non-parametric, such as DEA (Wade et. al. 2009; Fethi & Pasiouras 2010; Paradi et. al., 2013; Despotis et al., 2016; Fukuyama and Matousek, 2017; Sufian and Kamarudin, 2017).

Jahangoshai Rezaee (2015) introduced a multi-objective DEA (MODEA) model to remove the limitations of the conventional DEA models. He used the shapley value as a cooperative game. Omrani et al. (2015) combined bargaining game theory, principal component analysis (PCA) and data envelopment analysis (DEA) to obtain more realistic results with higher resolution power. Lozano (2012) proposed a cooperative DEA game based on the idea that different organizations can gain if they share data on the input consumption and output production of their processing units. Nakabayashi et al. (2006) deal with problems of consensus making among individuals or organizations with multiple criteria for evaluating their performance when the players are supposed to be egoistic; in the sense that each player sticks to his superiority regarding the criteria. This leads to a dilemma called "egoist's dilemma". Cooper et al. (2007) introduced a consensus-making method in a multiple criteria environment using a combination of DEA and cooperative game theory. It is demonstrated that both DEA *max* and *min* games have the same shapley value. Some researchers have also studied DEA games (Lozano, 2013; Hao et al., 2000; Lozano et al., 2015; Selten, 1991).

2.2 Satisficing Game Theory

Weaknesses of the DEA method have resulted in using modern techniques in the field of performance evaluation. One of the newest methods in this field is the satisficing game theory, introduced by Tchangani (2006). Satisfaction is a decision making strategy or a cognitive exploration method, which requires searching through available options until achieving an acceptable point (Stirling et al., 1999). This method conflicts with other optimal decision-making methods, which are trying to find the best answers. The term satisficing is a combination of two terms “satisfy” and “suffice” (Simon, 1956), and this concept is used for explaining decision-makers behavior in conditions in which an optimal solution can be determined.

Game theory is a branch of applied mathematics that is applicable in various sciences and tries to mathematically model the behavior governing a strategic situation (Meyerson, 1991). This situation emerges when the success of an individual is dependent on strategies that others select. Satisficing game theory was introduced by Bestougeff et al. (1998). Unlike the DEA method which tries to compare each DMU with an optimal DMU that probably is virtual, in satisficing game theory, the option “good enough” in terms of the calculated utility function is enough for us (Zhang & Gong, 2017). The “good enough” options are placed in the Satisficing Equilibrium Set (Brown, 2004). Definition of Satisficing Equilibrium Set is proportional to the definition of the utility function in the investigated decision-making problems. Therefore, especially in performance evaluation problems, Satisficing Equilibrium Set includes DMUs (Stirling, 2003).

Tchangani (2006) used the concept of satisficing game theory for the first time for evaluating the performance of 20 sales units in a wholesale. The results of his work show that the proposed method can overcome many fundamental weaknesses of the DEA method. Sohraiee and HosseinZadeh Lotfi (2010) have also used interval inputs and outputs based on Tchangani (2006) work, instead of point amounts in order to evaluate the performance of 20 branches of a bank in Iran. It should be noted that the only difference between these two works is in using interval inputs and outputs instead of fixed and no analysis is added to the results. While in this article, we have analyzed the impact of using interval inputs and outputs instead of fixed. Mahmoudi et al. (2019) presented a bargaining game model to evaluate performance in the DEA network with respect to sub-networks for a real case study in banking. The proposed model seeks to maximize the gap between each player return and maximize their breakpoints. In addition, Omrani et al.

(2019) used the DEA method with a cooperative game theory approach to evaluate the performance of the transport sector in a case study.

3 The Concepts of Satisficing Game Theory

Regarding evaluating the performance of branches by using concepts of satisficing game theory, a U set composed of DMUs is defined and for each $u \in U$, a select-ability function is defined as p_s (u) and a reject-ability function as $p_R(u)$, so that $p_S(u)$ is interest the rate of u for achieving the objectives of decision maker and $p_R(u)$ is the cost assigned to this unit. In order to calculate these satisficing functions, the following steps are necessary (Tchangani, 2006):

Calculating weights of select-ability w_j^S moreover, weights of reject-ability w_j^R through finding the average preference of K^{th} decision makers to the j^{th} input or output item, like the following:

$$w_j^S = \frac{\sum_{k=1}^{d} p_{kj}}{\sum_{j=1}^{m}\sum_{k=1}^{d} p_{kj}} \ , \quad w_j^R = \frac{\sum_{k=1}^{d} \sigma_{kj}}{\sum_{j=1}^{p}\sum_{k=1}^{d} \sigma_{kj}} \tag{1}$$

Where, p_{kj} and δ_{kj} are assigned weights by K^{th} decision maker to j^{th} output and input, respectively, which indicate select-ability or reject-ability of item j by k^{th} decision maker.

Calculating $w^S = [w_1^S w_2^S \ ... \ w_m^S]$ and $w^R = [w_1^R w_2^R \ ... \ w_p^R]$.

Calculating functions $g_S(u) = w^S o_u$ and $g_R(u) = w^R i_u$ for each unit $u \in \mathcal{U}$. Where, o_u and i_u are defined as:

$$o_u = [\frac{O_u^1}{\max\limits_{x \in \mathcal{U}}(O_x^1)} \quad \cdots \quad \frac{O_u^m}{\max\limits_{x \in \mathcal{U}}(O_x^m)}]^T, \ i_u = [\frac{I_u^1}{\max\limits_{x \in \mathcal{U}}(I_x^1)} \quad \cdots \quad \frac{I_u^p}{\max\limits_{x \in \mathcal{U}}(I_x^p)}]^T \tag{2}$$

Which are input and output normalized column vectors of unit u, and x^T stands for the transpose of the vector x. A normalization process is necessary before weighting because measurement unit of input and output items is not necessarily identical.

Calculating satisficing functions of p_S and p_R as the following:

$$p_S(u) = \frac{g_S(u)}{\sum_{x \in \mathcal{U}} g_S(x)} \ , \ p_R(u) = \frac{g_R(u)}{\sum_{x \in \mathcal{U}} g_R(x)} \ , \quad \forall \quad u \epsilon \mathcal{U} \tag{3}$$

The satisficing set of $\Sigma \subseteq U = \{u \in \mathcal{U} : \ p_S(u) \geq p_R(u)\}$, which indicates individual efficiency of DMUs. Equilibrium set ε (within-group efficiency of DMUs) is $\mathcal{E} = \{u \in \mathcal{U} : B(u) = \emptyset\}$ and ε includes units that are not the best units strongly. The set of satisficing equilibrium is $\mathcal{S} = \mathcal{E} \cap \Sigma$ and indicates completely efficient units. Set B(u), is complementary to the set ε which includes units that are strongly better than u and are defined as the following:

$$\begin{aligned} &\mathcal{B}(u) = \mathcal{B}_S(u) \cup \mathcal{B}_R(u) \\ &\mathcal{B}_S(u) = \{v\epsilon\mathcal{U} : p_R(v) < p_R(u) \ \ and \ \ p_S(v) \geq p_S(u)\} \\ &\mathcal{B}_R(u) = \{v\epsilon\mathcal{U} : p_R(v) \leq p_R(u) \ \ and \ \ p_S(v) > p_S(u)\} \end{aligned} \tag{4}$$

4 Practical Application

4.1 Satisfactory Performance Analysis

The main objective of performance evaluation method is identifying efficient and inefficient units and finally deciding about inefficient units. Based on the suggested approach, four types of performance could be imagined for a unit, which are a) efficient individually units (set Σ), b) efficient within-group units (set ε), c) efficient units (set $\mathcal{S}$), d) inefficient units (set $\mathcal{U} - \Sigma \cup \mathcal{E}$).

Through performing a sensitivity analysis on each of these sets and determining the rate of increase in output or reduction in input, we can improve the performance of each unit. Of course, provided that necessary changes in inputs and outputs are possible. It should be noted that change in inputs of branches can be directly controlled by a bank, but a change in outputs, although apparently is dependent on external factors, still is controllable by banks. For example, in the case of an increase of credit of branch, its expense will increase.

Required information for performance analysis by decision makers is summarized in sets Σ, ε, $\mathcal{S}$, and $\mathcal{B}(u)$.

Performance analysis of efficient within-group units: If one unit is $u \notin \Sigma$ (a member of the set $\mathcal{E} - \mathcal{S}$ that its members are efficient in terms of group and inefficient individually), through performing a sensitivity analysis we can determine how much should decrease input or increase output, while the performance of other units remains the same. In order to do this job, through solving inequalities (5), we can calculate sensitivity parameters $\delta_u^i \geq 0$ and $\gamma_u^i \geq 0$, for outputs and inputs, respectively (Tchangani, 2006):

$$\begin{aligned} &\frac{w^S(o_u+\delta_u)}{\sum_{v\in\mathcal{U},v\neq u} w^S o_u + w^S(o_u+\delta_u)} \geq \frac{w^R(i_u-\gamma_u)}{\sum_{v\in\mathcal{U},v\neq u} w^R i_v + w^R(i_u-\gamma_u)} \\ &0 \leq o_u + \delta_u \leq 1, 0 \leq i_u - \gamma_u \leq 1, \delta_u \geq 0, \ \gamma_u \geq 0 \end{aligned} \tag{5}$$

Where $\delta_u = [\delta_u^1 \delta_u^2 \dots \delta_u^m]^T, \gamma_u = [\gamma_u^1 \gamma_u^2 \dots \gamma_u^p]^T$. Finally, $\frac{\delta_u(i)}{o_u(i)}$ and $\frac{\gamma_u(i)}{i_u(i)}$ respectively are amounts that branch u should increase output i and decrease input j to be efficient individually when performance of other the units are unchanged.

Performance analysis individually units: Sensitivity analysis of set $\Sigma - \mathcal{S}$ by the help of set $\mathcal{B}(u)$ leads to identifying weaknesses of these units. The amount of increase in output ($\delta_u^{u^*}$) and reduction in input $\gamma_u^{u^*}$, required for within-group efficiency of these units are determined. Therefore, through defining $p_S(u) = p_S(u^*)$ and $p_R(u) = p_R(u^*)$, these parameters are obtained by solving inequalities (6) (Tchangani, 2006):

$$w^S \delta_u^{u^*} = \frac{p_S(u^*)(\sum_{v \in \mathcal{U}} w^S o_v) - w^S o_u}{1 - p_S(u^*)}, w^R \gamma_u^{u^*} = -\frac{p_R(u^*)(\sum_{v \in \mathcal{U}} w^R i_v - w^R i_u)}{1 - p_R(u^*)} \quad (6)$$
$$0 \le o_u + \delta_u^{u^*} \le 1, 0 \le i_u - \gamma_u^{u^*} \le 1,\ \delta_u^{u^*} \ge 0,\ \gamma_u^{u^*} \ge 0$$

A recessive unit u improves its efficiency by increasing outputs for $\delta_u^* = \max_{u^* \in B(u)} (\delta_u^{u^*})$ moreover, reducing inputs for $\gamma_u^* = \max_{u^* \in B(u)} (\gamma_u^{u^*})$ which their amounts are calculable by the following relations and the maximum occurs synthetically.

Performance analysis efficient units: Units of set $\mathcal{S}$can be considered as "good enough" or efficient units, because they use their resources more efficiently both in terms of individual and group. In the suggested method, there is no sensitivity analysis on efficient which means that how much change in inputs of branches maintains their efficiency unchanged, still they remain efficient, because in case of change in inputs in this category, branches should maintain within-group efficiency besides individual one and based on the definition of within-group efficiency, as here is no unit as reference for efficient units, there is no possibility of establishing within-group efficiency conditions. However, due to the output-based (output oriented) approach of the bank, the efficient branches (the branches which are identified as efficient), even if they are given the excess amount of inputs, are not forced to reduce the inputs. Because the aim is maximization of the outputs while the inputs are fixed.

Performance analysis inefficient units: The set $\mathcal{U} - \Sigma \cup \mathcal{E}$ includes completely inefficient units. They do not use their resources efficiently and have less output than other units. Branches' inefficiency is due to different factors, including a) inappropriate structure of human resources including resource shortage, poor performance, and inappropriate assignment of human resource to groups, b) the inappropriate building of branch that will cause customers' dissatisfaction and reduction of efficiency of the branch, c) inappropriate grading of the branch that prevents growth and productivity increase in the branch through limiting the authorization of branch. d) inappropriate distribution of branches in a network that has been caused proximity of the branch to other branches and reduction of its efficiency. e) Low economic potential of the region and lack of the possibility of growth.

It is essential to note that in fact from the perspective of development and regulation of branch network, when omission of branches will be justifiable, that the reason of branch inefficiency relates to its inappropriate place because of the low economic potential of the region or its proximity to other branches (cases 4 and 5). Otherwise, the inefficient branch can obtain the required productivity and efficiency, through offering solutions for present problems, including reorganization human resources of the branch, branch displacement to an appropriate building in the region near the present place or reevaluating the grading of the branch. While we are deciding to omit branches that their inefficiencies are not due to inappropriate place, will cause losing the market and opportunity for earning money in the region and leads to a reduction of profitability of the bank.

This issue reflects the necessity of performing sensitivity analysis after identification of inefficient branches through the suggested approach. At this stage, after determining the amount of increase in outputs (δ'_{u}) or decrease in inputs (γ'_{u}) to achieve a favorable situation of branch performance (individual and within-group efficiency simultaneously) if there is no possibility of improvement in them, then the identified branch is investigated as an option for the omission. The amounts of parameters from solving inequalities (13) are obtained:

$$\frac{w^S(o_u+\delta'_u)}{\sum_{v\in\mathcal{U},v\neq u} w^S o_u + w^S(o_u+\delta'_u)} \geq \frac{w^R(i_u-\gamma'_u)}{\sum_{v\in\mathcal{U},v\neq u} w^R i_v + w^R(i_u-\gamma'_u)}$$

$$w^S\delta'_u = \frac{\mathrm{p}_S(u^*)(\sum_{v\in\mathcal{U}} w^S o_v) - w^S o_u}{1-\mathrm{p}_S(u^*)}$$

$$w^R\gamma'_u = -\frac{\mathrm{p}_{\mathrm{R}}(u^*)\left(\sum_{v\in\mathcal{U}} w^R i_v - w^R i_u\right)}{1-\mathrm{p}_R(u^*)} \tag{7}$$

$$0 \leq o_u + \delta'_u \leq 1, 0 \leq i_u - \gamma'_u \leq 1,\ \delta'_u \geq 0,\ \gamma'_u \geq 0$$

4.2 Selecting Inputs and Outputs

Studies in the field of evaluating bank branches have used various evaluation methods; which often have the following functional objectives (Paradi, 2013). In the Production approach, branches are considered as units that use capital and human resources to make deposits and loans. In Intermediation approach, the process is considered, during which deposits and loans are converted. In Profitability approach, it is evaluated that how good branches make a profit by using their employees, assets and capitals.

Each approach leads to determine different parameters as inputs and outputs. Selecting inputs and outputs are completely affected by analysis objective, strategies and policies of the organization. Considering the profitability approach that is used in this work, inputs and outputs of satisficing game theory methodology have been defined in a way that calculated efficiency by this method realizes this objective. 5 input parameters and 5 output parameters defined in table (1) have been classified. It should be noted that one of the strengths of this method in comparison with DEA method, is that it does not need conditions of lack of correlation between inputs and outputs and also doubling of the number of DMUs relative to the total number of inputs and outputs for achieving the appropriate efficient border.

Table 1
Input and output parameters

Input indices	Output indices
1. Value per square meter property of the branch	1. Currency reserves
2. Personnel costs	2. Expenditures
3. Area of property	3. Fees
4. Branch position	4. Net profit facilities
5. Demands	5. The growth rate of currency reserves

- Considering the following points about inputs and outputs are essential:
- Branch grade is also considered as one of the inputs of the branch, because the facilities and jurisdiction of the branch are defined proportional to the branch grade. Of course, the importance degree of branch grade, which is equal to the maximum grade of branches – branch grade + 1.
- The growth rate of deposits is also considered as one of the outputs in this work as it is possible for a branch with a high amount of deposits to have inappropriate performance and negative growth of deposits in comparison with other branches.
- One of the conditions of drawing appropriate conclusions from the performance evaluation method is homogeneity of DMUs based on the type of their business. For a number of branches, some of the outputs such

as the amount of foreign currency deposits, are zero. This matter may cause a reduction of accuracy and discriminatory power of the method. For this reason, bank branches are divided into two sections, including foreign currency and Rial and each branch is evaluated in its own group.

4.3 The Results of Performance Evaluation

In this study, the satisficing game theory method of performance evaluation is applied to a group of 26 branches of bank Mellat. It should be mentioned that the results of this research have been utilized for performance evaluation of all the branches in bank Mellat but due to the amount of sensitivity analysis calculations we preferred to select a small sample in this work. In order to evaluate the suggested method, the results have been compared with those of DEA. The amounts of input and output of branches have been demonstrated in the appendix table (Table 1.A), but the numbers provided in this table have been multiplied by a constant coefficient due to the limitations for publishing the bank's information.

The results of Satisficing game theory method in performance evaluation are provided in table 2 by assuming equality in weights of inputs and outputs, in which, the branches have been divided into 4 sets of individually efficient, within-group efficient, completely efficient and inefficient branches. This division is done based on the results of select-ability and reject-ability functions (with values between zero and one) that are shown in the table with signs p_R and p_S, respectively, the calculation method of these functions are presented in section 4 in details. For example, branch 1 was individually efficient because $p_S > p_R$, but due to its weak performance in comparison with other branches, the mentioned branch is not efficient within the group and therefore, it is not completely efficient. The reason for the inefficiency of this branch is that $p_{S_2} > p_{S_2}$ and $p_{R_2} < p_{R_2}$, Which means that performance of this branch is worse than branch 2, because the amount of reject-ability function (input) of this branch is more than branch 2, while the amount of its select-ability function (output) is less than branch 2. A branch would be inefficient within the group even if its performance were worse than just one other branch, while within-group efficiency does not need to be worse than all the other branches in the group. For example, even though branch 12 has less select-ability function than all of the branches, it also has less reject-ability function than other branches, so we cannot consider it worse than another branch. Finally, branches that do not have individual or within-group efficiency are placed in an inefficient group of branches.

The results of DEA method in table 2 show that this method has identified 14 efficient branches and 12 inefficient ones; while the number of efficient branches identified by the suggested method is 6 and according to experts, they are closer to the reality. This result indicates more discriminatory power of the suggested method than DEA. Nevertheless, in the DEA method, we can also conduct an inter-branch reevaluation after each stage of implementation among branches which have been identified as efficient and reclassify them; however, this process is time-consuming.

In addition, the results show that the branches which have been identified as inefficient by this method are the same as inefficient branches of DEA method while some of the efficient branches of DEA have not identified as complete efficient here. Furthermore, the reason for their weak performance has accurately been determined. However, branches 20, 21, and 22 which have a score over 0.95 and are near to the efficient border in DEA method have been identified as branches having individual efficiency in the suggested method, which is a more accurate result according to the experts.

By conducting sensitivity analysis on identified inefficient branches by the suggested method, the required degree of change for these units to become efficient is calculable. The results of sensitivity analysis of an inefficient branch, individual and within-group efficiencies are provided in table 3. It should be noted that the amount of sensitivity analysis parameter for “growth rate of deposits” is considered zero, because the required increase rate for deposits is calculable by sensitivity parameter related to deposits.

Table 2

Comparing the results of the suggested method and DEA method

Number of branches	Results of the suggested method			Results of DEA	
	p_R	P_S	Performance of branches	Score of branches	Performance of branches
1	0.0441	0.0504	Individual efficiency	1	Efficient
2	0.0351	0.0532	Efficient	1	Efficient
3	0.0522	0.0451	Inefficient	1	Efficient
4	0.0381	0.0284	Inefficient	0.837	Inefficient
5	0.0481	0.0577	Efficient	1	Efficient
6	0.0423	0.0361	Inefficient	0.725	Inefficient
7	0.0413	0.0307	Inefficient	0.734	Inefficient
8	0.0384	0.0371	Inefficient	1	Efficient
9	0.0334	0.0421	Efficient	1	Efficient
10	0.0288	0.0310	Efficient	1	Efficient
11	0.0382	0.0334	Inefficient	0.849	Inefficient
12	0.0238	0.0199	Within-group efficiency	1	Efficient
13	0.0257	0.0210	Within-group efficiency	1	Efficient
14	0.0312	0.0363	Efficient	1	Efficient
15	0.0702	0.0635	Inefficient	0.91	Inefficient
16	0.0341	0.0384	Within-group efficiency	1	Efficient
17	0.0427	0.0747	Efficient	1	Efficient
18	0.0427	0.0412	Within-group efficiency	1	Efficient
19	0.0403	0.0425	Individual efficiency	1	Efficient
20	0.0375	0.0376	Individual efficiency	0.935	Inefficient
21	0.0355	0.0359	Individual efficiency	0.959	Inefficient
22	0.0429	0.0480	Individual efficiency	0.992	Inefficient
23	0.0385	0.0279	Inefficient	0.721	Inefficient
24	0.0345	0.0242	Inefficient	0.739	Inefficient
25	0.0370	0.0233	Inefficient	0.758	Inefficient
26	0.0324	0.0216	Inefficient	0.687	Inefficient

For example, the results of table 3 show that branch 1 with individually efficient will be an efficient if inputs reduction 51%, 50%, 15%, 0% and 12% and outputs increase 35%, 40%, 85%, 78% and 0%, respectively. For example, as 50% reduction of the second input (personnel cost) or 179% increase of the fourth output (net profit of loans) in branch 7 are not possible (results in table 3), this branch is an option for omission. The results of sensitivity analysis for all branches show that branches 7, 13, and 25 are appropriate options for elimination, because there is no opportunity to make any improvement in their inputs and outputs.

Table 3
Sensitivity analysis results

Number of branches	**Type of efficiency**	**Percent of reduction in inputs {input 1, input 2, input3, input 4, input 5}**	**Percent of increase in outputs {output 1, output2, output3, output4, output5}**
1	Individual efficiency	{12,0, 15, 50, 51}	{0, 78, 85, 40, 35}
7	Inefficient	{49, 50, 59, 0, 6}	{0, 179, 31, 110, 57}
12	Within-group efficiency	{3, 0,0,0, 0}	{0, 0, 0, 127, 0}

5 Conclusions

Considering the importance of bank branches as the main points of banking activities in terms of income, expenditures, and interaction with customers, having an efficient and effective branch network has always been a priority for banks. One of the measures done regarding the organizing of the branch network is the omission of inefficient branches. In this paper, satisficing functions based on cooperation game theory strategies have been utilized to evaluate the performance of branches, which instead of the optimal option is looking for "good enough" option. "Good enough" options are placed in satisficing equilibrium set. Definition of Satisficing equilibrium set is proportional to the definition of utility function in investigated decision-making problem. Therefore, particularly in performance evaluation issue, Satisficing equilibrium set includes units that are efficient individually and within-group. In order to determine individual and within-group efficiency, two select-ability and reject-ability functions are defined as a combination of inputs and outputs, respectively.

The suggested method of performance evaluation is applied to a group of 26 branches of bank Mellat. Implementation of the suggested method has led to analyzing branches' performance with more discriminatory power than the DEA method. Because the DEA method has identified 14 efficient branches, while the suggested method has identified just 6 of them as efficient branches and the rest 8 branches were inefficient. However, 12 efficient branches of DEA method have also been divided into different groups including individual efficient, within-group efficient, and completely efficient. Also, by conducting sensitivity analysis on inputs and outputs, feasible solutions for improving the efficiency of branches have been provided. Lastly, as the required changes have not been possible for branches 7, 13 and 25, these branches were introduced as options for the omission

References

Brown, R. (2004). Consideration of the Origin of Herbert Simon's Theory of 'Satisficing' (1933-1947), *Management Decision*, 42 (10): 1240–1256.

Cooper, W. W., Seiford, L. M., & Tone, K. (2007). *Data Envelopment Analysis*. Springer Press, US, Second Edition, 405-421.

Despotis, K. D., Koronakos, G., & Sotiros, D. (2016). Composition versus Decomposition in Two-Stage Network DEA: A Reverse Approach. *Journal of Productivity Analysis*, 45, 71-87.

Fethi, M. D., & Pasiouras, F. (2010). Assessing Bank Efficiency and Performance with Operational Research and Artificial Intelligence Techniques: A Survey. *European Journal of Operational Research*, 204, 189-198.

Fukuyama, H., & Matousek, R. (2017). Modelling Bank Performance: A Network DEA Approach. *European Journal of Operational Research*, Vol. 259, No. 2, 721-732.

Bestougeff, H., & Rudnianski, M. (1998). Games of Deterrence and Satisficing Models Applied to Business Process Modeling. *in: Proceeding of the AAAI Symposium*, Technical Report SS-98-05, 8-14.

Hao, G., Wei, Q., & Yan, H. (2000). The Generalized DEA Model and the Convex Cone Constrained Game. *European Journal of Operational Research*, 126(3), 515-525.

Lozano, S. (2012). Information Sharing in DEA: A Cooperative Game Theory Approach. *European Journal of Operational Research*, 222(3), 558-565.

Lozano, S. (2013). DEA Production Games. *European Journal of Operational Research*, 231(2, 1), 405-413.

Lozano, S., Hinojosa, M. A., & Marmol, A. M. (2015). Set-Valued DEA Production Games. *Omega*, 52, 92-100.

Martin, J. O., & Ariel, R. (1994). *A Course in Game Theory*. *MIT Press*, ISBN 0-262-65040-1.

Mahmoudi, R., Emrouznejad, A., & Rasti-Barzoki, M., (2019). A Bargaining Game Model for Performance Assessment in Network DEA Considering Sub-Networks: A Real Case Study in Banking. *Neural Computing and Applications*, 31, 6429–6447.

Myerson, R. B. (1991). *Game Theory: Analysis of Conflict*, Harvard University Press.

Nakabayashi, K., & Tone, K. (2006). Egoist's Dilemma: A DEA Game. *Omega*, 34(2), 135-148.

Omrani, H., Gharizadeh Beiragh, R., & Shafiei Kaleibari, S. (2015). Performance Assessment of Iranian Electricity Distribution Companies by an Integrated

Cooperative Game Data Envelopment Analysis Principal Component Analysis Approach. *International Journal of Electrical Power & Energy Systems*, 64, 617-625.

Omrani, H., Shafaat, K., Alizadeh, A., (2019). Integrated Data Envelopment Analysis and Cooperative Game for Evaluating Energy Efficiency of Transportation Sector: A Case of Iran. *Annals of Operations Research*, 274(1–2), 471–499.

Paradi, J. C., & Zhu, H. (2013). A Survey on Bank Branch Efficiency and Performance Research with Data Envelopment Analysis. *Omega*, 41, 61–79.

Rezaee, M. J. (2015). Using Shapley Value in Multi-Objective Data Envelopment Analysis: Power Plants Evaluation with Multiple Frontiers. *International Journal of Electrical Power & Energy Systems*, 69, 141-149.

Selten, R. (1991). *Game Equilibrium Models II*, Berlin Heidelberg: Springer Press, 85-163.

Simon, H. A. (1956). Rational Choice and the Structure of the Environment. *Psychological Review*, 63(2), 129–138.

Sohraiee, S., & HosseinZadeh Lotfi, F. (2010). A Satisficing Game Theory Approach for Efficiency Evaluation with Interval Data. *Applied Mathematical Sciences*, 4(27), 1337-1353.

Stirling, W. C. (2003). *Satisficing Games and Decision Making: With Applications to Engineering and Computer Science*. Cambridge University Press, ISBN: 0521817242.

Stirling, W. C., & Goodrich, M. A. (1999). Satisficing Games. *Information Sciences*, 114, 255-280.

Sufian, F., & Kamarudin, F. (2017). Forced Mergers on Bank Efficiency and Productivity: Evidence from Semi-parametric Malmquist Productivity Index. *Global Business Review*, 8, 19-44.

Tchangani, A. P. (2006). A Satisficing Game Theory Approach for Group Evaluation of Production Units. *Decision Support Systems*, 42, 778–788.

Wade, C., Seiford, D., & Larry M. (2009). Data Envelopment Analysis (DEA) –Thirty years on. *European Journal of Operation Research*, 192, 1-17.

Zhang, S. Z., & Gong, Z. W. (2017). DEA Game Cross Efficiency Method for Dynamic Change of Competitive and Cooperative between Decision Making Units. *Operations Research & Management Science*, 25(3), 22–27.

Appendix

Table 4
Amounts of input and output of example branches (amounts in millions of Rials)

The growth rate of currency reserves	Net profit facilities	Fees	Expenditures	Currency reserves	Demands	Branch position	Area of property	Personnel costs	Value per square meter property of the branch	number of rows
23	28,020	1,728	173,732	367,745	6,671	4	263	4,905	91	1
51	23,973	2,513	141,404	346,676	3,766	4	235	4,933	17	2
37	17,242	2,428	115,414	304,025	4,969	4	185	9,132	135	3
9	10,655	1,519	72,278	237,204	2,330	3	518	3,728	45	4
28	33,204	1,982	193,962	414,964	5,460	3	382	4,688	85	5
33	14,610	1,487	124,359	234,384	6,139	3	353	4,482	99	6
22	16,231	1,155	106,294	193,421	3,222	3	642	3,863	29	7
25	16,813	1,223	137,188	272,943	1,161	3	550	3,423	57	8
58	12,441	1,661	88,792	368,221	2,716	4	147	3,815	65	9
34	14,052	1,293	83,639	211,338	859	3	195	2,835	80	10
29	11,384	1,711	81,298	251,373	2,257	3	437	4,469	58	11
15	7,659	630	39,355	220,566	396	3	222	2,984	8	12
11	8,355	1,143	59,192	109,532	4,174	2	239	2,237	12	13
15	17,751	1,402	122,902	275,575	1,393	3	400	3,656	11	14
11	42,341	2,368	243,227	381,732	21,809	5	627	6,975	37	15
12	23,027	1,215	124,107	310,060	2,321	3	461	3,728	15	16
34	48,205	3,201	237,836	432,586	4,004	4	390	6,284	22	17
-8	18,141	1,371	135,344	438,190	2,272	3	529	4,842	73	18
154	6,834	660	80,864	307,323	185	2	343	2,739	230	19
25	18,545	1,490	131,436	241,969	4,161	3	461	3,623	41	20
58	16,454	1,080	113,057	214,880	2,968	3	241	3,629	107	21
29	23,737	1,901	141,648	365,923	3,837	4	230	5,138	113	22
-2	10,467	1,217	99,707	250,349	2,865	3	284	5,169	93	23
24	7,892	970	65,461	202,173	1,440	3	339	3,128	88	24
-1	12,072	855	74,665	213,081	1,026	3	336	3,332	120	25
12	6,319	1,074	42,005	217,104	2,029	3	240	3,734	75	26