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Performance Measurement with Data Envelopment Analysis in Service Industry: Banking Application

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Abstract
It is very important to have a performance measurement in order to make right decision, hence to realize our targets via help of these decisions in business world. However, performance measurement is a very vast concept and therefore needs to be described. In our research, we used Data Envelopment Analysis (DEA) method as a performance measurement tool. We managed to reach 21 Turkish Banks' data trough The Bank Association of Turkey and measured productivity and efficiency. This study yielded that 13 Banks were active while 8 of them were below efficiency limit and active institutions were found by analyzing data obtained from CCR (Charnes, Cooper, and Rhodes), data oriented DAE and improvement tables prepared for inactive banks.

Key words: Performance Measurement, Banking Sector, Data Envelopment Analysis, Efficiency measurement, Service Industry,.

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INTRODUCTION

Competitiveness of enterprises directly related with their use of resources efficiently and productively, furthermore sustainability of their rivalry requires them to improve their activities in the industry while keeping close eye on their performance. It is imperative that companies determine their recourse utilization efficiency in order to measure and evaluate their performance. Therefore firms run a series of analysis to understand how efficient they use their resources and Data Envelopment Analysis (DEA) is used widely among professionals to identify recourse usage efficiency. Even though it is possible to use rate analysis such as parametric functions, total factor productivity to measure efficiency and productivity, these methods remains incapable when businesses become large and organizations involve with service industry (referansgösterilmeli Performance measurement becomes very difficult when using DEA method without parameters.(doğrubirifadeolmamışolabilir). In this study, we obtained data from 21 Banks which are member of The Banks Association of Turkey and analysis carried out with data oriented DEA, CCR (açılımınedir), BBC (açılımınedir), and AM (additive method). As a result, efficient banks were identified, while potential betterment tables for inefficient banks were obtained.

THEORETICAL UNDERPINNING

Performance, productivity and efficiency are the terms that are close to each other and interrelated; however, they don't describe the same thing. Performance is mostly used as a general wording which involves productivity and efficiency.
Performance represents a very general description and could be described as one business' success degree which the business has attained in a given period. In other words, performance is qualitative and quantitative narration of where an individual or a group or an enterprise that is on a work has been able to reach on the way to the goal aimed at, which is related to that work (Ramanathan, R. 2003). When one talks about performance measurement, it should be understood as measurement of productivity or efficiency.
Productivity means the relation between output which a production or service unit produces and input which is used to produce this output (Cook, W.D., M. Kress, and L.M. Seiford, 1992). The simplest formula to calculate productivity mathematically is seen in a system which has one input and one output and is calculated as the following.

$$\text{Productivity}=\frac{\text{Output}}{\text{Input}}$$

Total Factor Productivity and Partial Factor Productivity come up in the systems having more than one output and more than one input. Partial Factor Productivity is described as follows.

$$. V_i = \frac{Y_i}{X_i}$$

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V_i: Partial Factor Productivity
Y_i: i. Output
X_i: i. Input

Partial Factor Productivity calculates only one of all inputs and outputs, independent from the others. When it is wanted to calculate one-by-one productivity of outputs and inputs or if there are one input and one output, it is a suitable method. To describe productivity in the systems which have more than one output and more than one input as a single value it is found by dividing the sum of weighted outputs by sum of weighted inputs by giving weight to outputs inputs.

$$\text{Productivity} = \frac{\text{sum of weighted outputs}}{\text{sum of weighted inputs}}$$

When all inputs and outputs are calculated Total Factor Productivity is also calculated, Total Factor Productivity is measured with indexes. Index numbers put forward price's and quantities' change in the course of time. (Zhu, J., 1996a)

$$TFP_{t_1 t_2} = \frac{\sum_{i=1}^{N} pit_2 \, qit_2}{\sum_{i=1}^{N} pit_1 \, qit_1}$$

TFP: Total Factor Productivity Index,
N : Output number
t_1, t_2: Time periods
p : Output prices
q : output quantity

Laspeyres, Pashe, Fisher, Tornqvist and Malmquist indexes can be counted as one of the most used indexes in the factor productivity. To be able to apply Total Factor Productivity, all inputs and outputs and weights of these parameters must be known. Being given weights correctly and being reached to input-output parameters cause difficulties in practice.

In this era technology and therefore production technology are changing rapidly, and as a result productivity is affected from these changes in the production environment.(Kale, 2009, s.3).Therefore, in the systems that have more than one input and output, it is not certain whether the measured productivity is the best productivity or not. It is because impossible to answer the question of "can more outputs be obtained with the same amount of inputs or can the same amount of outputs be obtained by using fewer amounts of inputs?"Answer to this question will yield the maximized productivity.

In order to maximize the productivity, it is necessary to understand what efficiency means.

Efficiency is, in a general sense, the degree of reaching the goal, which has been aimed at, of efficiency, a movement or a behavior as much as possible. Efficiency can be calculated with the formula as shown below.

$$Efficiency = \frac{\text{Standard Performance (Value)}}{\text{Real Performance(actual value)}}$$

Efficiency of a production unit can be described as the ratio between data, which has been observed, related to outputs and inputs, and is at optimum values. The goal of the production unit is to reach to a level which will be considered as optimum. Comparing data observed to optimum is made either by comparing maximum output as much as possible at a certain input level or by comparing minimum input as much as possible at a certain output level. (Zhu, J., 1996b) .Production efficiency lies at the base of productivity.

In another description, efficiency is efforts that businesses have spent to reach the goals which they have determined and as a performance indicator and, determines to what extent this goal has been able to be achieved.

Efficiency is the part of productivity. Productivity is not a relative concept because productivity of every unit can be measured alone. Because efficiencies of decision units cannot be determined independent from each other in the production system where there are a lot of outputs and inputs, it becomes a relative concept. It is not necessary to make comparisons with other decision unit to measure productivity. However other decision units that will be taken as a reference to calculate efficiency are necessary. One of the important stages of efficiency measurements is to decide on correct reference units.

DATA ENVELOPMENT ANALYSIS (DEA)

Yao and others (2007) say, data envelopment analysis (DEA) is an approach for measuring the relative efficiency of peer decision making units (DMUs) that have multiple inputs and outputs. Data envelopment analysis is also a method to determine the relative efficiencies of a set of organizational unit such as school or banks branches when there are multiple in commensurate inputs and outputs (Charnes et al., 1978). DEA was initially developed by Charnes et al. (1978) (CCR) and by Banker et al. (1984) (BCC) in order to evaluate the relative efficiency of similar economic production systems. Data Envelopment Analysis (DEA) is a nonparametric method for measuring the efficiency of a *decision-making unit* (DMU). BesdesDEA is a flexible method (W. Cook, L. Liang and J. Zhu, 2010), (K. Tone and M. Tsutsui, 2010), (F. Andre, I. Herrero, and L. Riesgo, 2010) and (J. Liu and W. Lu, 2010) that can be applied under different underlying economic assumptions and the returns to scale (L. Seiford and J. Zhu, 1999) yield different DEA models (J.H. Dula, 2002). For example, banks use labor and assets to generate deposits that are in turn used to generate load incomes. In such a setting, a DMU represents a two-stage process and intermediate measures exist in-between the two stages. The first stage uses inputs to generate outputs that become the inputs to the second stage. The first stage outputs are therefore called intermediate measures. The second stage then uses these intermediate measures to produce outputs. A key feature here is that the first stage's outputs are the only inputs to the second stage, i.e., in addition to the intermediate measures, the first stage does not have its own outputs and the second stage does not have its own inputs.Recent expositions with this application can be found in Chen and Zhu (2004), Kao and Hwang (2008), Chen, Liang and Zhu (2009) and Cook, Liang and Zhu (2010).

Farrell put forward a new measurement method that is not parametric, in a study in 1957. Depicted from this study, Charnes, Cooper and Rhodes used it in their articles known as (CCR) model in 1978. DEA has evolved fast regarding both pure science and methodology for the last two decates. As a result of this evolution, Banker, Charnesand Cooper not only measured, with CCR model, general technical productivity of service areas in the public sector under the constant profit assumption according to scale, but also measured scale and technical productivity with variable profit method, known as CCR method, according to scale in 1984. Therefore, as DEA unproductively resources have been measured; situation to scrutinize unproductively types has risen. Method completed its theoretical development to a large extend in 1990's. It was used in productivity analysis of inputs and outputs which are in deterministic structure until recently. With the studies directed to inputs and outputs that change probabilistically, DEA has also turned to a new area. (Seiford, L.M., and R.M. Thrall, 1990)

In contradistinction to a single input-single output in classical productivity analysis, DEA behaves on the basis of multi inputs-multi outputs. It has followed a fast process in practice in addition to fast theoretical development. Thousands of studies have carried out in a lot of public service areas such as hospitals, post offices, banking, courts, chemist's, transportation, police offices and education institutions. At first, comparative productivity in public institutions that doesn't involve with profit, DEA then have begun to be used commonly in measuring technical productivity of inter businesses that are in production and service sectors seeking a profit. Without Data Envelopment Analysis, carrying out analysis of complex organizations producing a lot of outputs is limited to analyze ratios of inputs and outputs. It is not usually possible to reach a certain result with these ratios. Therefore Data Envelopment Analysis is an alternative to insufficient methods.

Data Envelopment Analysis is a method of efficiency measuring without a parameter which was developed for measuring relative activities of economical decision units that look like each other regarding goods or services they produce.

METHODOLOGIES

In this study, we applied three performance measure methodologies: the Charnes, Cooper and Rhodes (CCR) Method, BCC and Additive Method. Charnes, Cooper and Rhodes method helps comprehend the DEA development to a more detailed level.BCC and CCR methods are focused on input and output and we know that if a model focuses on both input and output, that model is an Additive Method (Kaynak). We used three methods for measuring efficiency and productivity in performance.

The following sections briefly introduce these methodologies.

CCR Method

To allow for applications to a wide variety of activities, we use the term Decision Making Unit

(=DMU) to refer to any entity that is to be evaluated in terms of its abilities to convert inputs into outputs. CCR construction as the reduction of the multiple-output /multiple-input situation (for each DMU) to that of a single 'virtual' output and 'virtual' input. For a particular DMU the ratio of this single virtual output to single virtual input provides a measure of efficiency that is a function of the multipliers. In mathematical programming parlance, this ratio, which is to be maximized, forms the objective function for the particular DMU being evaluated, so that principally the mathematical programming problem may thus be stated as

1) Deals with evaluation of all activities.
2) Describes resources, inputs in other words, and determines the amount of not being efficient that described by BCC Model (1984).
3) Makes scalar and technical differentiation of not being efficient.
4) Determines exact technical efficiency at the operation level given

Mathematical structure of CCR method is given by the formula below
:

CCR Output Oriented– Primal Model:

$$\max z_0 = \emptyset$$

$$\emptyset Y_{r0} - \sum_{j=1}^{n} \lambda_j Y_{rj} + S_r^+ = 0 \quad r = 1, \ldots, s$$

$$\sum_{j=1}^{n} \lambda_j X_{ij} + S_i^- = X_{10} \quad i = 1, \ldots, m$$

$$\lambda, S^+, S^- \geq 0$$

$$minq_0 = \sum_{i=1}^{m} V_i X_{i0}$$

$$\sum_{r=1}^{s} \mu_r Y_{r0} = 1$$

$$\sum_{r=1}^{s} \mu_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} \leq 0 \quad j = 1, \ldots, n$$

$$\mu, V \geq 0$$

CCR Output Oriented–Dual Model:

In these models **s** shows output, **m** shows input, **n** shows number of decision makers. Comments of these models are like the input-oriented. In dual model, making related Decision Making Unit (DMU) inputs' weighted average minimum is intended. Weighted average of outputs of the decision maker is made equal to 1. And for every DMU, weighted output averages' being smaller than weighted input averages is another condition. According to this condition, weighted average of inputs of DMU, whose efficiency value is wanted to be calculated, is minimum 1. Thus, Efficiency value for efficient decision maker is 1, Efficiency value for inefficient decision maker is bigger than one (Seiford, L.M. ,and R.M. Thrall, 1990).

CCR Input Oriented–Dual Model i:

$$maxw_0 = \sum_{r=1}^{s} \mu_r Y_{r0}$$

$$\sum_{i=1}^{m} V_r X_{i0} = 1$$

$$\sum_{r=1}^{s} \mu_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} \leq 0 \quad j = 1, \ldots, n$$

$\mu, V \geq 0$

CCR Input Oriented– Primal Modeli:

$$\min z_0 = \theta$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} - S_r^+ = Y_{ro} \quad r = 1, \ldots, s$$

$$\theta X_{i0} - \sum_{j=1}^{n} \lambda_j X_{ij} - S_i^- = 0 \quad i = 1, \ldots, m$$

$$\lambda, S^+, S^- \geq 0$$

As seen from Dual model, in input oriented CCR model, weighted averages of outputs of each DMU in a row is tried to be made maximum. In constraints, weighted average of inputs of DMU is made equal to 1. Hence, weighted average of inputs of each DMUis 1. It makes weighted average of later outputs of constraint smaller than weighted average of inputs. Thus, output-input ratio can be maximum 1 for each decision maker. In the light of this information, optimum output average that can be found for a decision maker can be maximum 1 and this means that decision maker is efficient. For DMU's which are inefficient, in other words, which remain under the efficiency limit, outputs' weighted average, in other words, efficiency value is below 1. (Seiford, L.M.,and R.M. Thrall, 1990).

BCC Method

Throughout this article we confine attention to technical aspects of efficiency so that no price or cost Data are required. Suppose, therefore, that we have n DMUs (decision making units) where each DMUj, j ¼ 1; 2; . . . ; n, produces the same s outputs in (possibly) different amounts, yrj (r ¼ 1; 2; . . . ; s), using the same m inputs, xij (i ¼ 1; 2; . . . ;m), also in (possibly) different amounts. The efficiency of a specific DMUo can be evaluated by the ''BCC model'' of DEA––as introduced in Banker et al. (1984)––which we present in ''envelopment form'' as follows:

BCC Input Oriented – Primal Model:

$$\min z_0 = \theta$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} - S_r^+ = Y_{ro} \qquad r = 1, \ldots, s$$

$$\theta X_{i0} - \sum_{j=1}^{n} \lambda_j X_{ij} - S_i^- = 0 \quad i = 1, \ldots, m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda, S^+, S^- \geq 0$$

BCC Input Oriented–Dual Model:

$$maxw_0 = \sum_{r=1}^{s} \mu_r Y_{r0} + \mu_0$$

$$\sum_{i=1}^{m} V_r X_{i0} = 1$$

$$\sum_{r=1}^{s} \mu_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} + \mu_0 \leq 0 \quad j = 1, \ldots, n$$

$\mu, V \geq 0 \mu_0\ free$

BCC models are very similar to input oriented CCR models. Difference in Primal model is that sum of λs is equal to 1. A new variable (u_0) has been added to dual Model. The structure of efficiency limit has changed with these alterations. Efficiency line, going through the origin in CCR model, doesn't have to go through the origin in BCC model. With this structure, BCC model is different from CCR model. There is no difference in considering models with regard to other variables (Seiford, L.M.,and R.M. Thrall, 1990).

BCC Output Oriented – Primal Model:

$$\max z_0 = \emptyset$$

$$\emptyset Y_{r0} - \sum_{j=1}^{n} \lambda_j X_{ij} + S_i^+ = 0 \qquad i = 1, \ldots, s$$

$$\sum_{j=1}^{n} \lambda_j X_{ij} + S_r^- = X_{io} \qquad r = 1, \ldots, m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda, S^{+}, S^{-} \geq 0$$

BCC Output Oriented Dual Model:

$$min q_0 = \sum_{i=1}^{m} V_i X_{i0} + V_0$$

$$\sum_{r=1}^{s} \mu_r Y_{r0} = 1$$

$$\sum_{r=1}^{s} \mu_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} - V_0 \leq 0 \quad j = 1, \ldots\ldots, n$$

$\mu, V \geq 0$

$$V_0\ free$$

As seen above, Model here is like CCR model just as it is in input oriented BCC model.

In contradistinction to output oriented CCR model, sum of λs is equal to 1 in primal model. In dual model, v_0 variable is used. The objective here is to provide inconstant profit according to scale. (Seiford, L.M., and R.M. Thrall, 1990).

Additive Method

CCR and BCC evaluate models are output and input focused. If a model evaluates these two types of focusing together, it is an additive model. Main objective here is to deal with input surplus and output insufficiency at the same time and to reach to the farthest point to inefficient decision unit which is above efficiency limit. Inefficiency is found with (1-Efficiency)

As a result of this model, an efficiency score value is not obtained. Whether decision makers are efficient or not is determined by looking up idle variable values. If both idle variables' values are zero, that decision unit is efficient according to this model.

To be able to find the results of Data envelopment analysis model, objective function must be solved again by using related decision unit's parameters for each decision unit. (Banker, R.D., Charnes, A. and Cooper, W.W., (1984).

AN APPLICATION IN BANKING SECTOR

The objective of this study is to determine the efficiencies of the banks in Turkey via DEA, to determine reference clusters for inefficient banks and to reveal potential betterment tables.

Constraints, Method and Application of the Study

Data used in this study were obtained from the website of the Banks Association of Turkey. Financial tables consolidated in September 2009 were used. CCR-I Input oriented data envelopment analysis technique was used. Outputs and inputs used are shown in Table-1.

Insert table 1 here

The number of banks whose all input and output information in Table-1 were collected from the Banks Association of Turkey is 21. DMU number which will be used for DEA must be at least: the number of outputs +the number of inputs + 1 or (the number of outputs + the number of inputs)*2. In this study, since it was (4+3) = 7 or (4+3)*2 = 14, all banks were used.

The banks used in the study and output and input values used for these banks are shown in Table 2.

Insert table 2 here

In this study, DEA-Solver program was used.

With DEA-Solver program, CCR-I method was used. When making a solution for the banks in Table 2, values below were obtained.

Correlation values between inputs and outputs are shown in Table 3.

Insert table 3 here

Summary of Efficiency Values of the banks is shown in Table 4, Summary of Potential betterment values of inefficient banks is shown in Tables 5,6,7,8,9,10,11 and 12.

DMU (Decision Making Unit) means decision making unit. In this study, DMUs are the banks.

Score Data: shows values of input-output parameters for DMUs. For each DMU, value opposite to it shows efficiency value. It shows that if efficiency values are 1 DMU is efficient exactly and it is not necessary to make betterment.
Projection: shows goal values for DMUs. Because Projection (goal) value of DMUs whose efficiency values are 1 are the same Difference value becomes 0 therefore its alteration % also becomes 0.
Difference shows it is not necessary to make betterment for DMUs whose difference value is zero. For the values different from zero, it shows that if the value is negative, the same amount must be reduced, if the value is positive, the same amount must be increased.
% column of the table shows alteration ratio of difference value. Values obtained for the banks in our study are given in Appendix-2. According to these values, efficiency values of 13 banks were found as 1. That is, these banks are full efficient and it is not necessary to make betterment in any parameter.
8 banks weren't found full efficient. Efficiency values are shown in Table.5 in summary.

Insert table 4 here

These results are shown in Diagram.1.

Insert diagram 1 here

Reference clusters for inefficient banks were found as below.
Potential betterments which will be made are determined by values of the bank which was taken as a reference.
Reference clusters
For Şeker Bank: TürkiyeVakıflarBankası, Turkish Bank, Deniz Bank,
For TekstilBankası: TürkiyeVakıflarBankası, ArapTürkBankası, Deniz Bank,
For TürkEkonomiBankası: TürkiyeVakıflarBankası, Turkish Bank, Deniz Bank,
For TürkiyeİşBankası:TürkiyeVakıflarBankası, Anadolubank, ArapTürkBankası,
For YapıveKrediBankası: TürkiyeVakıflarBankası, ArapTürkBankası, ArapTürkBankası, Denizbank, BankPozitifKrediveKalkınmaBankası
For EurobankTekfen: TürkiyeCumhuriyetiZiraatBankası, TürkiyeVakıflarBankası, Akbank, TürkiyeGarantiBankası,
For Finans Bank: TürkiyeVakıflarBankası, ArapTürkBankası, Denizbank, HSBC Bank, BankPozitifKrediveKalkınmaBankası,
For ING Bank: TürkiyeVakıflarBankası, Denizbank, HSBC Bank, BankPozitifKrediveKalkınmaBankası
Betterments necessary for the banks which were found inefficient to become full efficient are shown in Tables 5, 6, 7,8,9,10,11 and 12.

Insert table 5 here

According to Table.5, to become efficient, Şekerbank must reduce the number of the branches by 106, the number of personnel by 1.662, non-interest expenses by 56.686.000 TL, interest expenses by 79.652.000 and increase total credit amount by 402.637.000 TL.
The table must be considered in the same way for the inefficient banks.

Insert table 6 here

According to Table.6, to become efficient, TekstilBankası A.Ş must reduce the number of the branches by 10.77 (galibayanlışyazılmı), the number of personnel by 315.48, non-interest expenses by 22.320.9330 TL, interest expenses by 24.721.99 TL, and increase net profit by 24.194.35.

Insert table 7 here

According to Table.7, To become efficient, TürkEkonomiBankası A.Ş. must reduce the number of the branches by 69,86, the number of personnel by1.576,56, non-interest expenses by129.974,93 TL, interest expenses by 153.960,17 TL, and increase net profit by 39.893,00.

Insert table 8 here

According to Table.8, To become efficient, TürkiyeİşBankası A.Ş. must reduce the number of the branches by 100.55, the number of personnel by1.074,02, non-interest expenses by1.117.246,82 TL , interest expenses by 212.829,16 TL, and increase total credit amount by 8.095.079,99.

Insert table 9 here

According to Table.9, to become efficient, YapıveKrediBankası A.Ş must reduce the number of the branches by 139,12, the number of personnel by594,66, non-interest expenses by75.263,52TL, interest expenses by 119.510,34 TL.

Insert table 10 Here

According to Table.10, To become efficient, EurobankTekfen A.Ş must reduce the number of the branches by 17,17, the number of personnel by303,71, non-interest expenses by36.164,93, interest expenses by 138.011,68 TL.

Insert table 11 here

According to Table.11, to become efficient, Finans Bank A.Ş. must reduce the number of the branches by 107,64, the number of personnel by2.555,83, non-interest expenses by208.023,61 TL, interest expenses by 314.383,23 TL.

Insert table 12 here

According to Table.12, to become efficient, ING Bank A.Ş must reduce the number of the branches by 84,21, the number of personnel by737,16, non-interest expenses by50.613,90 TL, interest expenses by 92.081,07 TL.

CONCLUSION

We were able to analyze those of banks whose information obtained from the banking sector web site. Efficient banks were determined by using input oriented DEA model. Those of DMUs found out for inefficient banks as a reference to be able to be efficient and betterment tables were given. 13 out of 21 banks were found efficient and the rest of 8 banks were found to be below the efficiency level. In a general sense, inefficient banks must consider the number of their branches and their personnel, their non-interest expenses, their interest expenses seriously. As a result, because parameters to be compared are free, it is not necessary to determine weights for parameters, and its application is practical, DEA appears as a strong method that would be used to measure relative performances of similar DMUs. DEA, however, doesn't show ideal performance. DEA is a model which determines efficient ones from among decision making units which were included into the study and produces values regarding betterments which are needed to be done in their parameters for inefficient KVBs to be able to be efficient. Therefore, it is necessary to consider the choice of KVBs which will be included into the study after parameters to be compared determined.

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TABLES AND GRAFİK

Table.1. Output-input parameters used in the study.

Input parameters	**Output parameters**
The number of the Branches	Total deposit
The number of the personnel	Total credit and dept
Non-interest expenses	Net profit
Interest expenses	

Table 2: Banks and their input and output parameters

Name of The Bank	The Number of Branches	The Number of Personnel	Non-Interest Expenses (thousand tl)	Interest Expenses (thousand tl)	Total Deposit (thousand tl)	Total Credit amount (thousand tl)	Net Profit (thousand tl)
TürkiyeCumhuriyetiZiraatBankası A.Ş.	1.316	22.198	1.360.494	6.468.964	94.411.917	33.797.352	2.673.064
TürkiyeHalkBankası A.Ş.	669	12.505	959.588	2.953.230	40.902.632	30.512.079	1.234.586
TürkiyeVakıflarBankası T.A.O.	545	10.153	1.529.363	2.615.880	43.337.595	33.383.126	975.294
Akbank T.A.Ş.	878	14.714	1.637.895	3.795.682	57.896.633	43.187.163	2.012.599
Alternatif Bank A.Ş.	46	999	81.610	188.554	2.379.092	2.543.741	70.088
Anadolubank A.Ş.	86	1.851	117.217	177.478	2.925.782	2.922.351	118.286
Şekerbank T.A.Ş.	256	3.938	323.099	454.004	6.252.784	4.549.100	134.945
TekstilBankası A.Ş.	45	940	80.448	103.263	1.301.828	1.354.833	15.056

Turkish Bank A.Ş.	25	276	28.863	24.408	420.467	206.174	3.776
TürkEkonomiBankası A.Ş.	334	5.871	552.675	736.100	9.728.311	9.088.999	202.516
TürkiyeGarantiBankası A.Ş.	788	16.828	2.009.615	4.531.814	64.292.597	53.424.584	2.158.258
Türkiyeİşbankası A.Ş.	1.093	22.473	3.978.754	4.453.281	69.390.387	50.099.915	2.020.530
YapıveKrediBankası A.Ş.	838	14.333	1.814.078	2.880.560	43.176.764	38.569.361	1.282.176
ArapTürkBankası A.Ş.	6	230	22.967	11.956	161.704	311.167	21.977
Denizbank A.Ş.	450	7.789	659.404	897.600	15.001.168	16.348.018	429.704
EurobankTekfen A.Ş.	42	743	88.474	254.492	1.824.678	1.232.060	31.112
Finans Bank A.Ş.	461	10.107	890.906	1.346.414	15.777.465	16.351.761	529.423
Fortis Bank A.Ş.	297	5.007	13.687	612.483	6.595.729	7.588.570	79.195
HSBC Bank A.Ş.	336	6.430	70.534	567.416	8.903.029	8.654.118	223.601
ING Bank A.Ş.	359	6.110	419.515	763.217	9.777.096	11.160.239	177.266
BankPozitifKrediveKalkınmaBankası A.Ş.	4	263	52.109	46.201	88.054	1.106.396	23.201

Table.3. Correlation values between inputs and outputs

	The Number of Branches	**The Number of Personnel**	**Non-Interest Expenses**	**Interest Expenses**	**Total Deposit**	**Total credit amount**	**Net Profit**
The Number of Branches	1						
The Number of Personnel	0,988735467	1					
Non-Interest Expenses	0,826675168	0,87711542	1				
Interest	0,9597740	0,9568074	0,801012	1			

Expense s	06		7				
Total Deposit	0,9605514 92	0,9567105 4	0,820430 4	0,997297 89	1		
Total credit amount	0,9011568 62	0,9284389 3	0,904517 3	0,905811 51	0,913077 6	1	
Net Profit	0,9461536 43	0,9471139 7	0,81634	0,990315 95	0,989782 8	0,925038 81	1

Table.4. Efficiency values in summary

DMU	Score
TürkiyeCumhuriyetiZiraatBankası A.Ş.	1,0000000000
TürkiyeHalkBankası A.Ş.	1,0000000000
TürkiyeVakıflarBankası T.A.O.	1,0000000000
Akbank T.A.Ş.	1,0000000000
Alternatif Bank A.Ş.	1,0000000000
Anadolubank A.Ş.	1,0000000000
Şekerbank T.A.Ş.	0,8245547881
TekstilBankası A.Ş.	0,7605920094
Turkish Bank A.Ş.	1,0000000000
TürkEkonomiBankası A.Ş.	0,7908434086
TürkiyeGarantiBankası A.Ş.	1,0000000000
TürkiyeİşBankası A.Ş.	0,9522084586
YapıveKrediBankası A.Ş.	0,9585114217
ArapTürkBankası A.Ş.	1,0000000000
Denizbank A.Ş.	1,0000000000
EurobankTekfen A.Ş.	0,5912366552
Finans Bank A.Ş.	0,7665032988
Fortis Bank A.Ş.	1,0000000000
HSBC Bank A.Ş.	1,0000000000
ING Bank A.Ş.	0,8793513906
BankPozitifKrediveKalkınmaBankası A.Ş.	1,0000000000

Table.5. Summary of Şekerbank Efficiency Values and Potential Betterment Ratios

DMU	Score Data	Projection	Difference	%
Şekerbank	**0,82**			
The Number of the branches	256,00	149,88	-106,12	-41,45%
The Number of personnel	3.938,00	2.275,95	-1.662,05	-42,21%
Non-Interest Expenses	323.099,00	266.412,83	-56.686,17	-17,54%
Interest Expenses	454.004,00	374.351,17	-79.652,83	-17,54%
Total Deposit	6.252.784,00	6.252.784,00	0,00	0,00%
Total Credit Amount	4.549.100,00	4.951.737,78	402.637,78	8,85%
Net Profit	**134.945,00**	**134.945,00**	**0,00**	**0,00%**

Table.6. Summary of TekstilBankası A.Ş Efficiency Values and Potential Betterment Ratios

DMU	Score Data	Projection	Difference	%
TekstilBankası A.Ş.	**Scor 0,76**			
The Number of the branches	45,00	34,23	-10,77	-23,94%
The Number of personnel	940,00	624,52	-315,48	-33,56%
Non-Interest Expenses	80.448,00	58.127,07	-22.320,93	-27,75%
Interest Expenses	103.263,00	78.541,01	-24.721,99	-23,94%
Total Deposit	1.301.828,00	1.301.828,00	0,00	0,00%
Total Credit Amount	1.354.833,00	1.354.833,00	0,00	0,00%
Net Profit	**15.056,00**	**39.250,35**	**24.194,35**	**160,70%**

Table.7. Summary of TürkEkonomiBankası A.Ş Efficiency Values and Potential Betterment Ratios

DMU	Score Data	Projection	Difference	%
TürkEkonomiBankası A.Ş.	**Scor 0,79**			
The Number of the branches	334,00	264,14	-69,86	-20,92%
The Number of personnel	5.871,00	4.294,44	-1.576,56	-26,85%
Non-Interest Expenses	552.675,00	422.700,07	-129.974,93	-23,52%
Interest Expenses	736.100,00	582.139,83	-153.960,17	-20,92%
Total Deposit	9.728.311,00	9.728.311,00	0,00	0,00%
Total Credit Amount	9.088.999,00	9.088.999,00	0,00	0,00%
Net Profit	**202.516,00**	**242.409,00**	**39.893,00**	**19,70%**

Table.8. Summary of TürkiyeİşBankası A.Ş. Efficiency Values and Potential Betterment Ratios

DMU	Score Data	Projection	Difference	%
TürkiyeİşBankası A.Ş.	**Scor 0,95**			
The Number of the branches	1.093,00	992,45	-100,55	-9,20%
The Number of personnel	22.473,00	21.398,98	-1.074,02	-4,78%
Non-Interest Expenses	3.978.754,00	2.861.507,18	-1.117.246,82	-28,08%
Interest Expenses	4.453.281,00	4.240.451,84	-212.829,16	-4,78%
Total Deposit	69.390.387,00	69.390.387,00	0,00	0,00%
Total Credit Amount	50.099.915,00	58.194.994,99	8.095.079,99	16,16%
Net Profit	**2.020.530,00**	**2.020.530,00**	**0,00**	**0,00%**

Table.9. Summary of YapıveKrediBankası A.Ş Efficiency Values and Potential Betterment Ratios

DMU	Score Data	Projection	Difference	%
YapıveKrediBankası A.Ş.	**Scor 0,96**			

The Number of the branches	838,00	698,88	-139,12	-16,60%
The Number of personnel	14.333,00	13.738,34	-594,66	-4,15%
Non-Interest Expenses	1.814.078,00	1.738.814,48	-75.263,52	-4,15%
Interest Expenses	2.880.560,00	2.761.049,66	-119.510,34	-4,15%
Total Deposit	43.176.764,00	43.176.764,00	0,00	0,00%
Total Credit Amount	38.569.361,00	38.569.361,00	0,00	0,00%
Net Profit	**1.282.176,00**	**1.282.176,00**	**0,00**	**0,00%**

Table.10. Summary of EurobankTekfen A.Ş Efficiency Values and Potential Betterment Ratios

DMU	Score Data	Projection	Difference	%
EurobankTekfen A.Ş.	**Scor 0,59**			
The Number of the branches	42,00	24,83	-17,17	-40,88%
The Number of personnel	743,00	439,29	-303,71	-40,88%
Non-Interest Expenses	88.474,00	52.309,07	-36.164,93	-40,88%
Interest Expenses	254.492,00	116.480,32	-138.011,68	-54,23%
Total Deposit	1.824.678,00	1.824.678,00	0,00	0,00%
Total Credit Amount	1.232.060,00	1.232.060,00	0,00	0,00%
Net Profit	**31.112,00**	**50.215,64**	**19.103,64**	**61,40%**

Table.11. Summary of Finans Bank A.Ş. Efficiency Values and Potential Betterment Ratios

DMU	Score Data	Projection	Difference	%
Finans Bank A.Ş.	**Scor 0,77**			
The Number of the branches	461,00	353,36	-107,64	-23,35%
The Number of personnel	10.107,00	7.551,17	-2.555,83	-25,29%
Non-Interest Expenses	890.906,00	682.882,39	-208.023,61	-23,35%
Interest Expenses	1.346.414,00	1.032.030,77	-314.383,23	-23,35%
Total Deposit	15.777.465,00	15.777.465,00	0,00	0,00%
Total Credit Amount	16.351.761,00	16.351.761,00	0,00	0,00%
Net Profit	**529.423,00**	**529.423,00**	**0,00**	**0,00%**

Table.12. Summary of ING Bank A.Ş. Efficiency Values and Potential Betterment Ratios

DMU	Score Data	Projection	Difference	%
ING Bank A.Ş.	**Scor 0,88**			
The Number of the branches	359,00	274,79	-84,21	-23,46%
The Number of personnel	6.110,00	5.372,84	-737,16	-12,06%
Non-Interest Expenses	419.515,00	368.901,10	-50.613,90	-12,06%
Interest Expenses	763.217,00	671.135,93	-92.081,07	-12,06%
Total Deposit	9.777.096,00	9.777.096,00	0,00	0,00%
Total Credit Amount	11.160.239,00	11.160.239,00	0,00	0,00%
Net Profit	**177.266,00**	**287.693,79**	**110.427,79**	**62,29%**

Grafik.1. Efficiency values Diagram