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Research Article

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Benchmark Forecasting in Data Envelopment Analysis for Decision Making Units

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Abstract

The purpose of this paper is to develop a benchmark model for efficiency evaluation in future. With forecasting the efficiency of organizations, managers could plan and determine that strategy. One of the most important methods for evaluating decision making units (DMUs) is DEA. Although DEA is a powerful method in evaluating DMUs, it does have some limitations. One of the most important limitations of this method is the result of the evaluation is that the efficiency calculated was based on previously existing data and the results are not proper for forecasting the future changes regarding inputs and outputs required for the units to be considered as efficient. The aim of this paper is to propose a model to enlighten and forecast how inputs and outputs alter through system dynamics and simulation. For this purpose, we design feedback loops for forecasting inputs and outputs. Then we use CCR model to forecast the efficiency.

Keywords : Bank efficiency; Performance Evaluation; Data Envelopment Analysis (DEA); System dynamics; Simulation; Efficiency forecasting; Benchmark.

1 Introduction

Nowadays, due to continuous change in economic conditions, evaluating the performance of industrial and economical units has become one of the most important factors in their improvement. In order to improve the performance and have a good position in comparison to other units, industrial units have to be evaluated using scientific methods. One of the most important methods for evaluating decision making units (DMUs) is DEA, which was introduced by Charness et al (1978) [6] and developed by Banker et al (1984) [3].

Data envelope analysis (DEA) provides a useful service management and benchmarking technique to evaluate profit and nonprofit sector organizations. Previous research on the application of DEA to banking operating efficiency subordinated to financial holding companies was mostly carried out around 2010, for example, Chiou (2009) [9], Li (2009) [26], Chao, Yu and Chen (2010) [5] and Chen, Chiu and Huang (2010)

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[8], Kao, Lin and Xu (2012) [24], etc. The ignorance of internal operational structures of the banks may be unable to identify sources of inefficiency within the production process. Additionally, the effect of carryover assets was to allow banks to carryover some assets from one period to the next [19]. Moreover, although DEA is a dominant means in evaluating DMUs, it does have some limitations. One of the main limitations of this method is the result of the evaluation. As DEA models use historical data and their results are not suitable for forecasting the future, managers are not able to use these results for planning and strategic management. Another problem in DEA is the benchmark obtained from classic DEA models which might be considerably different than the DMUs that are under evaluation, therefore, in many papers, other researchers have tried to make the under evaluated DMU as close as possible to the image of inefficient DMU as benchmark unit.

To solve these problems several methods have been proposed. For example Thanassoulis and Dyson (1992) introduced a method for finding projections on efficient frontier [43]. Golony (1988) presented a method using goal programming to allow the decision maker to explore the PPS [20]. Stewart (2010) used a goal programming structure to find points on efficient frontier which are realistically achievable by DMUs too [40].

Moreover, the above-mentioned studies treat the entire production process as a black box, and only suitable for measuring the efficiency of a single operational process, where decision making units for example banks are assumed to have multiple bank production processes [22]. Therefore, we need to use a model that can consider all internal and external relationship between branches as well as inputs and outputs. In order to use a model with above specification we can use some approach such as regression, expert opinion, the least-squares method, regression analysis, saturation curve method, curve extension method, or other forecasting methods. These mothed can consider only one or two factors, however, we need a model that can consider whole indexes as inputs and output. It is important to say that one of the methods to consider whole inputs and outputs as well as their relationships is System Dynamic (SD).

In this paper the first problem is our hub. Strategic planning is very significant for managers. If managers know how to change the inputs and outputs in future, they can predict the future efficiency. So the focus of this paper is to forecast the inputs and outputs of DMUs.

It should be mentioned that mostly all the generated statistical prediction models, for instance, the least-squares method, regression analysis, saturation curve method, curve extension method, etc all are made according to semi-mathematical models configuration [12]. It is conspicuous that the configuration formulated based on these models is regarded as a term of cause-effect. Furthermore, figuring out the prediction methods, for example fuzzy prediction, dynamic prediction, and grey dynamic modeling, etc are all formulated in regard to semi-structured prediction, so are considered as a close capability of prediction concerns under uncertainty, on the other hand, for data scarcity and subjects management, straightforwardly, a type of famous modeling as grey dynamic modeling has been developed by Deng, 1982 [11] which is suitable for restrictive data condition and sample for prediction. Researchers have developed fuzzy logic in grey dynamics system, and opportunity in grey fuzzy dynamic prediction design [7].

The system dynamic techniques have been developed since 1960s by MIT University researcher team who were supervised by Forrester ,In fact, systems dynamics utilization was for diagnosing, comprehension system components movement and behaviors analyzing, whose capability for both simple and complex modeling has been examined by Mukherjee and Roy (2006) [29], further information, in this test the result of changes in variable interactions and consequently their future behavior in various time periods have been identified, also the predication of inputs and outputs for system prediction is done by system dynamics utilization. In Fact, in order to have the best evaluation of the performance characteristics, the best conclusion and original system duplication, we had better to utilize simulation, since, system development over time is an ordinary process, whose characterization will lead to

simulation model, which is very interesting for researcher, conspicuously, these models are based on a combination of relatively assumptions to system performance.
Simulation models can give you an analytical means to anticipate the effect of variation in an existing system as well as the performance of a new system with many different features. In fact, researchers must have accurate perception about system and its approach, because various parts of a system are in interaction with each other, but this perception can be achieved by all components observation and related interaction among them, on the other hand, system movement, behavior recognition, understanding and analyzing all are done by systems. Studying on system dynamics with high dynamic behavior and its effects on the future of the system and decision making methods for the considered situation in the study all have been well followed very precisely by Mukherjee and Roy in 2006 [29], furthermore, based on SD methodology principles, the system behavior analyze, via a dynamic simulation model, has been done too.
SD methodology introduction as a simulation methodology for analysis and long-term decision making tool to solve complicated industrial management problems was done by Jay Forrester in 1960s [16], but in fact, system dynamics utilization (SD) approach is for model simulation, Furthermore system dynamic modeling application on efficiency measurement originated from industrial dynamics. SD methodology is acquired to understand the behavior of a complex, dynamic social-technological-economic-political (STEP) systems in order to demonstrate, how system structure and utilized policies in decision making, govern system behavior, also concentration on the system structure comprising of various interaction and feedback loop is done by SD, since the SD approach is focused on the object of different system variables dynamic interaction capturing and analyzing their effect on policy decisions over the long time.
The current article is comprised as following, Section 2 provides literature review, Section 3 introduces a system dynamics model for inputs and outputs prediction in Iranian banks, Section 4 describes the DEA benchmark for DMUs and section 5 presents a practical study in Iranian banks. In this section we apply the proposed model for benchmark forecasting in Iranian banks. And section 6 is conclusion.

2 Background

2.1 Data envelopment analysis

The most widely used method of evaluation of the banking industry is data envelopment analysis or DEA [14], a nonparametric technique used in operation research for estimating production efficiency in decision making units (DMUs). DEA is a linear programming based methodology which can evaluate DMUs qualitatively and quantitatively and calculate multiple inputs and outputs, the term DMU stands for decision making unit which can be used either for comparing different firms or evaluating the efficiency of one firm over the time.
For the first time DEA has been introduced by Charnes, Cooper and Rhodes (CCR) in 1978 [6], and evolutionary form of the CCR the model famous as BCC by Banker et al. in 1984 [3], in recent years, so many researches started studying very carefully on these and development of various models is noticeable. These models generally differ as view of orientation, disposability, diversification, returns to scale, measurement type.
The DEA efficiency measurement as view of underlying concept is as an efficient frontier function. Furthermore, we will have emergence a set of efficient and inefficient units, but inefficient units analysis consist of two aspects, First, it can demonstrate the maximum input level for output accomplishment, Secondly, it can demonstrate the highest output level accomplished for given amount of inputs, the approaches in this way are called "minimal principle of efficiency" and "maximum principle of efficiency respectively.

2.2 DEA Models

The concept of efficiency is derived from physical and engineering science and indicates the relationship between inputs and outputs. Charnes et al. (1978) [6] introduced the ratio definition of efficiency, also known as the CCR

ratio definition, which generalizes the single-output to single-input ratio definition used in classical science to multiple outputs and inputs not including requiring pre-assigned weights. The main strength of the DEA model as it is applied in this study lies in its ability to combine multiple inputs and outputs into a single summary measure to select the most efficient unit.
Let x_{ij}, i=1,...,m, and y_{rj}, r=1,..., s, be the ith input and rth output, respectively, of the jth DMU, j = 1...n. The DEA model for measuring the relative efficiency of DMU_o under an assumption of constant returns to scale is the CCR model [6].

$$\max \sum_r^k u_r y_{ro}$$

$$\begin{aligned} S.t \quad & \sum_{i=1}^{m} v_i x_{io} = 1, \qquad (2.1)\\ & \sum_{r=1}^{k} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \quad j = 1, ..., n\\ & v_i \ge 0, i = 1, ..., m,\\ & u_r \ge 0, r = 1, ..., k. \end{aligned}$$

We can say that the dual model of model (2.1) is:

$$\begin{aligned} & \min \theta \qquad (2.2)\\ S.t \quad & \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{io}, \quad i = 1, ..., m,\\ & \sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{ro}, \quad r = 1, ..., k,\\ & \lambda_j \ge 0, \qquad j = 1, ..., n. \end{aligned}$$

The following BCC input oriented value-based [3] model can be used to assess efficiencies.

$$\begin{aligned} & \max \sum_{r}^{k} u_r y_{ro} + u_0 \qquad (2.3)\\ S.t \quad & \sum_{i=1}^{m} v_i x_{io} = 1,\\ & \sum_{r=1}^{k} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + u_0 \le 0, j = 1, ..., n\\ & v_i \ge 0, i = 1, ..., m,\\ & u_r \ge 0, r = 1, ..., k. \end{aligned}$$

Also he dual of model (2.3) is:

$$\begin{aligned} & \min \theta \qquad (2.4)\\ S.t \quad & \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{io}, \quad i = 1, ..., m,\\ & \sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{ro}, \quad r = 1, ..., k,\\ & \lambda_j = 1, \lambda_j \ge 0, \qquad j = 1, ..., n. \end{aligned}$$

2.3 System dynamics model

System dynamics (SD) is a discipline of research into system feedback structure and behavior developed by Professor Jay W. Forrester of the Massachusetts Institute of Technology (MIT). SD is a system analysis method that uses computer simulations to simulate the structure and the dynamic behavior of economic, social, and ecological systems [41]. Allington et al.(2017) used the method of system dynamics to construct an ecosystem model of human, natural, and land use in pastures in Inner Mongolia [2]. Wu and Ning (2018) used the system dynamics method to analyze the energy-environment-economy system, and clearly discussed the economic, energy and environmental interactions and influencing factors [46]. Fang et al.(2017) divided the urban ecosystem into a population subsystem, an economic subsystem, and a resource environment subsystem, and analyzed the relationship between these three subsystems [13].
System dynamics is focused on system thinking [42], but takes the additional steps of structuring and testing a computer simulation model. The method of system thinking has been used for over 30 years [16], and is a useful method for understanding large-scale complex management problems. System dynamics is designed with system thinking concepts (Dyson and Chang ,2005). This method requires constructing the causal loop diagram or stock and flow diagram to form a system dynamic model for applications. Several works can be found in the literature review such as Forrester, [16, 18], Randers, (1980) [33], Richardson and Pugh, (1980) [35], Mohaoatra (1994) , Bui and Loebbecke (1996) [4], Larson et al. (1997) [25], Smith and Ackere, (2002) [38], Ronkko, (2007) [36].

System dynamics can be applied to a wide range of problem domains such as strategy, PM, corporate planning, demand forecasting, public management, business systems by Sterman, (2000), [39], Bui and Loebbecke, (1996) [4], Smith and Ackere, (2002) [38], Yim et al., (2004) [47], Suryani et al., (2010) [42], ecological systems by Grand et al., (1997) [21], social-economic systems by Forrester, [17], [18], Meadows (1973) [27], agricultural systems by Qu and Barney, (1998) [31], Saysel et al., (2002) [37], environment system by Vizayakumar and Mohapatra, (1991) [?], Ford, (1999) [15], Wood and Shelley, (1999) [45], Abbott and Stanley (1999)[1], Deaton and Winebrake, (2000) [10], quality systems by Larson et al., (1997) [25], nonlinear systems by Ronkko, (2007) [36], knowledge decision making by Yim et al., (2004) [47], Otto, (2008) [30] and marketing by Richardson and Otto, (2008) [34].
To build a system dynamics model, first, the problem must be identified. In this stage we must find the real problem, identify the key variable and concepts and determine the time horizon [42]. In the next stage the dynamic hypothesis must be defined. In this stage the researcher develops a causal loop diagram. This diagram explains causal links among variables. This diagram must then be converted into a flow diagram. The third stage is formulation. After the flow diagram is designed, the system description should be translated into level, rate and auxiliary equations [42]. The next stage is testing and the final stage is policy formulation and evaluation.

2.4 Developing the base model

Systems dynamics approach is utilized to make the model and systems performance measurement. SD methodology can study and model complicated systems, since is the case for prediction benchmark in DEA. It can help to have a better understating about how different input and output will affect total organizations efficiency, which is made according to the conceptual how inputs react to the organizations output, because understanding of the relation between inputs and outputs factors caused better prediction about how inputs and output changes can be done.
But to understand the convenience of the modeling approach, it must be considered initially, what purpose the modeler may have of modeling [23]. Otherwise understanding essentiality whether the system dynamics can or cannot be useful for our purpose cannot be identified
The system dynamic approach is selected for complicated problems due to complexity relations between inputs and outputs .SD study follows the objective, for example, desired goal achievement via system modification, on the other hand, a system border is defined and system model will be made. In SD modeling, we have systematic procedural steps as [32]:

- Problems and goals definition;
- A causal loop/feedback diagram of the system should be described;
- model structure formulation (i.e. developing the flow diagram, arrow designator and the format of dynamics modeling system in the form of VENSIM equations);
- Gathering the preliminary data/base ,data required for model operation either from historical data and/or from discussion with executives/planners who knows and have experience about the system under study these are the preliminary value of all the variables level, constants and policy data;
- Model reinforcement on some criteria suitable for achieving enough confidence in the model; and
- Testing different various policy actions by model utilization to find the best way to fulfill the prearranged goals.

The major component of the dynamics system model is the feedback loops. The feedback loops are divided into two classes of variables. The first classes are the rate variables and the second classes are the levels variables [42].
Morecroft (1988) [28]emphasized that model conceptualization begins with causal loops and moves to rate/level flow diagrams, and finally, to explicit equations capturing the diagram structure.
Causal loop diagramming is an important means which helps the modeler to conceptualize the real

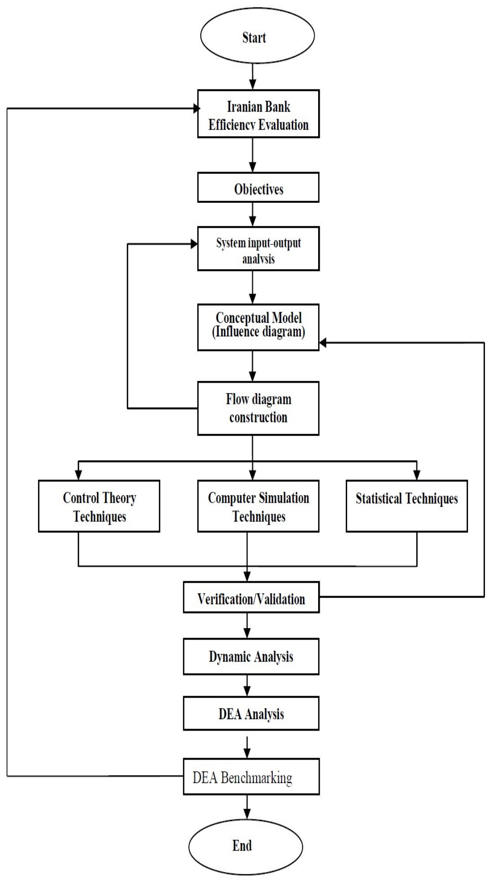

Figure 1: DEA Benchmarking with S.D.

world system in terms of feedback loops. It is especially vital to make out the key variables of Iranian banks before developing a causal loop diagram for the efficiency evaluation of Iranian banks. To model the efficiency evaluation, we consider the flowchart in Figure 1.
SD procedural steps as explained above were used in developing the SD model for Iranian banks.

3 System dynamics model for Iranian Banks

By reviewing the related backgrounds of efficiency indices on banking evaluation measures, several efficient indices about the banking industry have been acquired. Some of these efficient indices are shown in below. The major components of the Iranian banks efficiency are:

- Antiquity
- Area
- Equipment
- Person score
- Saving Account
- Long term saving
- Short term saving
- Cash account
- Other deposits
- Profits
- Non-interest Income
- Personal
- .

By using the metrics obtained from the previous section, and via making further inquiries, key indices were recognized. In the initial list, fifteen criteria were determined. Then, in order to select the ultimate criteria, a banking evaluation criteria checklist containing three main parts was prepared, validated, and distributed among 150 banking experts as respondents. Among the 150 questionnaires distributed to respondents, only 123 questionnaires were returned completely to the researchers and out of the 123 returning questionnaires, 110 questionnaires were accepted and analyzed. Finally, the selected index analyzed. The major components of the Iranian banks efficiency are:

- Antiquity
- Area
- Equipment
- Person score
- Saving Account
- Long term saving
- Short term saving
- Cash account
- Other deposits

Table 1: List of inputs and outputs in Iranian banks

Inputs	Outputs
Antiquity	Saving Account
Area	Long term saving
Equipment	Short term saving
Person Score	Cash account Other deposits

Table 2: Inputs and outputs forecasting with system dynamics (one month later).

Branch Code	Personal Score	Saving Account	Cash Account	Long term Account	Short term Account	Other Deposits
C1	390.8082	2.55E+10	7.59E+11	1.05E+12	2.91E+11	7.64E+11
C2	301.3225	8.32E+09	1.86E+11	2.48E+11	1.29E+11	5.16E+11
C3	192.1104	5.79E+09	1.04E+11	1.39E+11	1.14E+11	1.51E+11
C4	163.9281	7.99E+09	9.96E+10	9.75E+10	5.86E+10	1.87E+11
C5	116.1659	3.75E+09	1.35E+11	1.2E+11	4.35E+10	2.77E+11
C6	59.95642	3.43E+09	4.17E+11	4E+11	1.69E+11	9.08E+10
C7	116.1659	3.75E+09	1.35E+11	1.2E+11	4.35E+10	2.77E+11
C8	319.2041	3.36E+10	3.25E+11	4.82E+11	1.24E+11	3.22E+12
C9	233.673	1.65E+10	6.05E+10	2.45E+11	8.53E+10	1.53E+11
C10	85.18075	5.94E+09	3.52E+10	2.77E+10	2.23E+10	3.53E+10
C11	210.6558	9.32E+09	1.7E+11	6.81E+10	5.57E+10	6.48E+11
C12	228.0441	1.39E+10	5.9E+10	2.29E+11	7.77E+10	2.8E+11
C13	92.4086	1.92E+10	1.91E+10	8.12E+10	3.22E+10	1.09E+11
C14	87.54256	1.08E+10	4.46E+10	2.57E+10	1.67E+10	6.9E+10
C15	163.4919	8.34E+09	4.05E+10	1.29E+11	5.59E+10	1.37E+11
C16	252.6559	1.29E+10	6.12E+10	1.98E+11	1.2E+11	2.19E+11
C17	109.9077	6.97E+09	3.44E+10	5.74E+10	3.02E+10	9.39E+10

These indexes are separated into two categories. The first category is input and the second is output. Input and output indexes are shown in the Table 1.
From these indexes, antiquity, area and equipment are static, and the others are dynamic. So static indexes such as antiquity, area and equipment are not applied in the system dynamics model, as they are fixed and do not change. Hence, major components of the Iranian banks system dynamics are:

1) Input
   - Person score
2) Output
   - Saving Account
   - Long term saving
   - Short term saving
   - Cash account
   - Other deposits

In this case the person score, saving account, long-term saving account, short time saving account and the cash account are variables, the sum of four accounts is the rate variable, and the recourse branch is the level variable. A flow diagram is functional for showing the physical infor-

Table 3: Input Index.

Branch Code	Antiquity	Area	Personal Score	Equipment
C1	8	3000	367.9442361	581552337.3
C2	8	3000	263.9830553	329756380.7
C3	8	3000	171.5849816	244250023.5
C4	8	3000	151.4177097	223095029.9
C5	8	2493	110.0206631	82560025.85
C6	8	1290	55.48405199	88902512.51
C7	8	2600	118.7120936	177045031.7
C8	8	1086	300.5514315	197721279.3
C9	8	2431	212.006436	198725036.8
C10	8	2570	84.86485045	128975956.3
C11	8	1712	198.9479591	213646248.9
C12	8	2185	216.982523	291498087.3
C13	8	2953	83.94163853	101194629.9
C14	8	3000	145.4529598	159016273.3
C15	8	1999	81.33189049	101573764.1
C16	8	2218	245.4883906	214352549.2
C17	8	1272	104.8530919	139265102.5

mation flows in the SD model. Figure. 2 shows the details of the diagram developed for analyzing the inputs and outputs.
In this investigation, the gathering method is an interview with experts and documents and records studying. In order to make a relation among parts of the system and an effective variable on the branch source, 17 bank branches are chosen arbitrarily. According to the experts and the banks branches, the feedback loops are obtained. The feedback loops relation is illustrated in Fig 2. Diagrams and equations are used in order to program the language for computer simulation. System approach is used in order to study the aims of sets and systems by modeling. Numerous software is used in dynamics system modeling. Effective variables on the branch source are gathered as documents and records from 2007 to 2009, and regression analysis is utilized to make a relation among the variables.
According to Figure 2, there are nine variables in the cause-effect diagram. These variables and their effects on each other are recognized by interviewing experts, also, the relation between the variables is obtained by regression analysis.

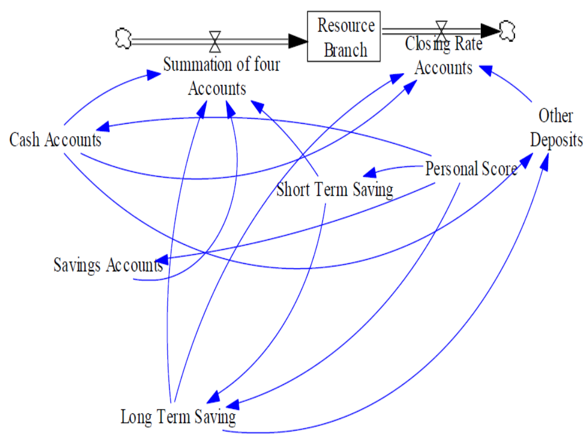

Figure 2: Flow Diagram of Iranian bank S.D.

3.1 System Dynamics Result

In this section, the simulation result is shown. For example, the C2 branch is chosen and the

Table 4: Output Index.

Branch Code	Saving Account	Cash Account	Long term Account	Short term Account	Other Deposits
C2	9820388712	1.52655E+11	2.48276E+11	1.02506E+11	5.1751E+11
C3	6329514427	1.03968E+11	1.4697E+11	66024781997	2.60913E+11
C4	9484794507	79030941300	93207695922	46727216250	1.53478E+11
C5	4559761815	1.21181E+11	1.08618E+11	44254543948	3.52373E+11
C6	3941169604	1.83998E+11	3.73189E+11	1.50884E+11	98889222816
C7	23637507142	85056709575	1.53187E+11	74401171103	1.18761E+11
C8	24684395079	1.03624E+11	4.13677E+11	1.2072E+11	2.3664E+12
C9	15568935025	55156741268	1.97519E+11	67961747000	1.85377E+11
C10	9461123759	51774109854	36352016411	27556365243	38991692268
C11	10997481500	1.72098E+11	62047931548	49691059739	5.49476E+11
C12	18264033265	59517198434	2.20933E+11	90768253821	4.70077E+11
C13	22238768245	21779156203	74877963897	38039285527	79568817340
C14	10000602183	51390130356	1.24202E+11	57508431346	1.82374E+11
C15	12873169282	52818537167	32648445185	16430412740	92383300417
C16	14339197619	51197380387	1.89068E+11	85927081970	3.93845E+11
C17	8135679341	27539891732	50824382926	25091077003	1.28373E+11

Table 5: DEA Benchmarking and efficiency forecasting.

DMUs	Efficiency	S_1^-	S_2^-	S_3^-	S_4^-	S_1^+	S_2^+	S_3^+	S_4^+	S_5^+
C1	1.0000	8.9E+3	2.3+2	1.8E+9	0.0	3E+11	1E+12	0.0	1E+11	1E+13
C2	0.4873	1.4E+3	0.0	1.2E+8	0.0	0.0	1E+11	1E+11	1E+10	1E+11
C3	0.4107	8.2E+2	0.0	6.2E+7	0.0	0.0	7E+10	8E+10	5.7E+9	8E+11
C4	0.4902	7.0E+2	0.0	4.5E+7	0.0	1E+10	1E+11	9.95E+10	0.0	7E+11
C5	0.4921	2.3E+3	0.0	1.6E+7	5.5559	1.9E+9	7E+10	0.0	7.9E+9	8E+11
C6	1.0000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C7	1.0000	4.2E+3	0.0	2.0E+8	9.5100	1E+10	2E+11	1E+11	0.0	2E+12
C8	1.0000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C9	0.6379	1.4E+3	0.0	5.6E+7	2.2197	0.0	7E+10	1E+11	2.9E+9	2E+12
C10	0.5930	2.4E+3	0.0	8.1E+7	6.2235	7.3E+9	9.94E+10	4E+10	0.0	9E+11
C11	0.5268	8.8E+2	0.0	7.7E+7	2.5582	2E+10	2E+11	0.0	6.8E+9	1E+12
C12	0.7666	1.6E+3	0.0	1.7E+8	2.7622	0.0	1E+11	2E+11	6.3E+9	2E+12
C13	1.0000	1.1E+4	1.6E+2	8.0E+7	0.0	1E+12	3E+12	3E+12	0.0	5E+11
C14	0.5554	2.6E+3	0.0	7.0E+7	4.4375	0.0	9.95E+10	9.97E+10	5.6E+9	1E+12
C15	0.7201	2.0E+3	0.0	5.5E+7	6.7806	2E+10	1E+11	6E+10	0.0	9.64E+12
C16	0.5916	6.7E+2	0.0	3.0E+7	0.0	0.0	9.90E+10	2E+11	1.4E+9	1E+12
C17	0.5761	0.0	0.0	3.6E+7	2.5008	5.1E+9	5E+10	4E+10	0.0	5E+11

next diagram forecasts the simulation result. The first variable which is considered is all of the four accounts and the forecasted results are illustrated in Figure 3. The second variable

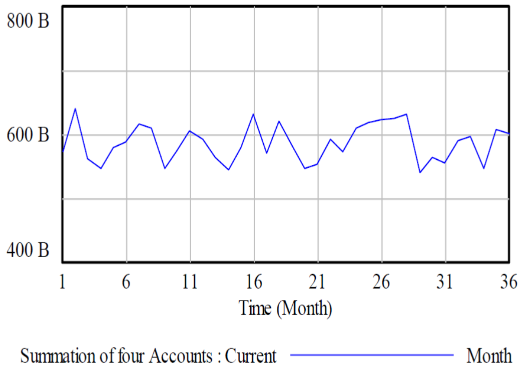

Figure 3: Graph for Summation of Four Accounts.

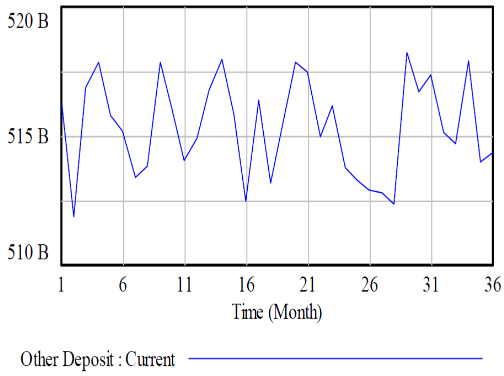

Figure 4: Graph for Other Deposit

which is considered is other deposits and is presented in Figure 4.

The third variable which is considered is branch sources and is shown in Figure 5.

As can be seen in the above figure, system dynamics model can predict 36 months. But, in this study we use only the predicted data of one month; the data is shown in Table 2.

4 Benchmarking with DEA

Benchmarking is particularly practical when there is no objective standard available for defining effective performance. So it is used in managing services because it is difficult to define the

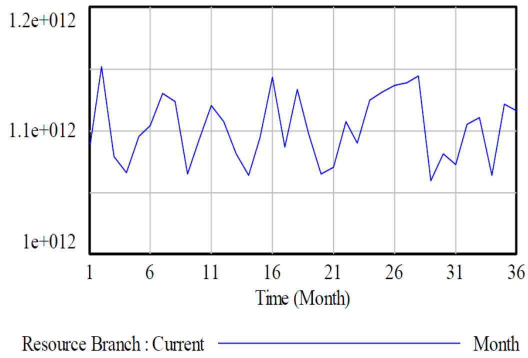

Figure 5: Graph for Resource Branch

service standard in comparison with the manufacturing standard.
One of the ways a benchmark is presented is by applying a DEA model. Consider the set of DMUs including DMU$_j$, j=1,,n with m inputs and s output s such that $x_j = (x_{j1}, , x_{jm})$, $y_j = (y_{j1}, , y_{js})$ are inputs and outputs, respectively. Let the CCR model with oriented input be as follows:

$$\min \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{k} s_r^+) \tag{4.5}$$

$$s.t$$

$$\begin{array}{ll} \sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io}, & i = 1, ..., m, \\ \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro}, & r = 1, ..., k, \\ \lambda_j \geq 0, & j = 1, ..., n, \\ s_i^- \geq 0, & i = 1, ..., m, \\ s_r^+ \geq 0, & r = 1, ..., s. \end{array}$$

Then the reference set is defined as shown below: Reference set=$\{j : \lambda_j^* > o\}$ and $\tilde{x}_o = \theta^* x_o - s^{-*}$ and $\tilde{y}_o = y_o + s^{+*}$ are benchmarks gained from DEA, but the gained benchmark from the DEA is not suitable in practice, as DEA is used as an instrument for the evaluation of units in the past, and the result of the evaluation will not be accurate, as previously existing data was used. In this paper the active and useful units are distinguished by a combination of DEA through a prediction technique, which there by presents a benchmark.
Reference units could be determined for all

inefficient units and an improved solution could be presented in the future.
By applying the present inputs and outputs data for under evaluation units and forecasting the amount of other units in the next position, it is possible to get to the relative efficiency of all DMUs in the future.

$$DMU_1^{k+1} : (x_{11}^{k+1}, ..., x_{1m}^{k+1}, y_{11}^{k+1}, ..., y_{1s}^{k+1})$$
$$\vdots$$
$$DMU_p^{k} : (x_{p1}^{k}, ..., x_{pm}^{k}, y_{p1}^{k}, ..., y_{ps}^{k})$$
$$\vdots$$
$$DMU_n^{k+1} : (x_{n1}^{k+1}, ..., x_{nm}^{k+1}, y_{n1}^{k+1}, ..., y_{ns}^{k+1})$$

According to the result of forecasting and introducing a new pattern for inefficient units, the rate of change of the inputs and outputs data can be adjusted so as to reach an efficient unit in future. So with this benchmark, Reference units could be determined for all inefficient units and an improved solution could be presented in the future.

5 Practical study

In this section we apply the proposed model to benchmark forecasting in Iranian banks. In these banks inputs are antiquity, area, equipment and person score, and outputs are saving account, long term saving account, short term saving account, cash account and other deposits. These inputs and outputs are shown in Table 1. The data about these inputs and outputs are shown in Table 3 and Table 4. Table 3 and Table 4 show the present data. With apply the system dynamics for inputs and outputs prediction, we gain inputs and outputs prediction. The prediction data about these inputs and outputs are shown in Table 2. Table 2 show the prediction data for 17 Iranian bank branches.
In order to present a suitable benchmark for the evaluation of a branch in March 2001 the following steps are taken.

1) We consider the inputs and outputs of C2 branch in March 2001 (present data that are shown in Table 3 and 4).

2) For other branches, the outputs and inputs of the next period, April 2001 (prediction data that are shown in Table 2), are considered.

3) By applying the CCR model and data given by Table 2, 3 and 4, the evaluation of the C2 branch is obtained.

For the evaluation of other branches, a method like that of the C2 branch is repeated. The evaluation results are shown in Table 5.
For the C2 branch $\tilde{x}_o = \theta^* x_o - s^{-*}$ and $\tilde{y}_o = y_o + s^{+*}$ are benchmark gained from DEA. As can be seen in Table 5, for the C2 branch, we have:
θ=0.4873, s_1^-=1.4E+3, s_2^-=0, s_3^-=1.2E+8, s_4^-=0, s_1^+=0, s_2^+=1E+11, s_3^+=1E+11, s_4^+=1E+10 and s_5^+=1E+11. So, if the inputs change to

$$\tilde{x}_1 = \theta x_1 - s_1^- = 0.4873 \times 8 - (1.4E + 3)$$
$$\tilde{x}_2 = \theta x_2 - s_2^- = 0.4873 \times 3000 - 0.0000$$
$$\tilde{x}_3 = \theta x_3 - s_3^- = 0.4873 \times 263.9830 - (1.2E + 8)$$
$$\tilde{x}_4 = \theta x_4 - s_4^- = 0.4873 \times 329756380.7 - 0.0000$$

and the outputs change to

$$\tilde{y}_1 = y_1 - s_1^+ = 9820388712 + 0.0000$$
$$\tilde{y}_2 = y_2 - s_2^+ = (1.52655E + 11) + (1E + 11)$$
$$\tilde{y}_3 = y_3 - s_3^+ = (2.48276E + 11) + (1E + 11)$$
$$\tilde{y}_4 = y_4 - s_4^+ = (1.02506E + 11) + (1E + 10)$$
$$\tilde{y}_5 = y_5 - s_5^+ = (5.1751E + 11) + (1E + 11)$$

Then C2 branch becomes efficient. These quantities are benchmark forecasting for C2 branch. So, modified inputs and outputs, benchmark forecasting data for C2, are strategy for this branch.

6 Conclusions

This paper is written based on the DEA problem. One of the problems is that the result of the evaluation is based on previously existing data, rendering the results unsuitable for forecasting efficiency. So a method was developed to create a benchmark. Since efficiency in DEA models is based on inputs and outputs, we must forecast the inputs and outputs in future first. For this aim, we use the system dynamics and simulation. In this analysis, system dynamics models were developed for the predication of inputs and outputs. With SD we can forecast the inputs and outputs of DMUs. This result is then applied to the DEA model. The importance of the system dynamics framework is that it focuses on information feedback control to organize the available information into a computer simulation model. By using a feedback structure the dynamics system can lead to understanding how inputs and outputs can be changed. In this method the information and the relation between them are very important. So by identifying the main purpose, the objective and the clear relation among indexes, the model can be implemented successfully. This method was applied in Iranian banks. First, the inputs and outputs in Iranian banks were determined. The antiquity, area, equipment and person score are inputs and saving account, long term account, short term account, cash account and other deposits are outputs. Then with expert ideal, the feedback loops and causal loops were designed, and using VENSIM software, the inputs and outputs were forecasted. These inputs and outputs were then applied in the CCR model. With the obtained results, a suitable benchmark is introduced for inefficient banks. It is noteworthy that according to the decision maker ideal, different technologies such as fixed return to scale, variable return to scale, weight restrictions, etc can be used.

References

[1] M. D. Abbott, R. S. Stanley, Modeling groundwater recharge and flow in an upland fracture bedrock, *System Dynamics Review* 15 (1999) 163-184.

[2] G. R. H. Allington, W. Li, D. G. Brown, Urbanization and environmental policy effects on the Capacity: Taking Beijing City as the Case, *Energy Procedia* 105(2017) 3493-3498.

[3] R. Banker, A. Charnes, W.W. Cooper, Some models for estimating technical and scale inefficiencies in data envelopment analysis, *European Journal of Operational Research* 9 (1984) 1078-1092.

[4] T. Bui, C. Loebbecke, Supporting cognitive feedback using system dynamics: A demand model of the global system of mobile telecommunication, *Decision Support System* 17 (1996) 83-98.

[5] C. M. Chao, M. M. Yu, Chen Measuring the performance of financial holding companies, *The Service Industries Journal* 30 (2010) 811-829.

[6] A. Charnes, W. W. Cooper, E. Rhodes, Measuring the efficiency of decision making units, *European Journal of Operational of Operational Research* 6 (1978) 422-444.

[7] H. W. Chen, N. B. Chang, Prediction of solid waste generation via grey fuzzy dynamic modeling, *Resources Conservation and Recycling* 29 (2000) 1-18.

[8] Y. C. Chen, Y. H. Chiu, C. W. Huang, Measuring super-efficiency of financial and nonfinancial holding companies in Taiwan: An application of DEA model, *African Journal of Business Management* 4 (2010) 3122-3133.

[9] C. C. Chiou, Effects of financial holding company act on bank efficiency and productivity in Taiwan, *Neurocomputing* 72 (2009) 3490-3506.

[10] M. L. Deaton, J. J. Winebrake, Dynamic Modeling of Environment Systems, *Springer-Verlag, NewYork,* (2000).

[11] J. L. Deng, Control problems of grey systems, *System Control Letter* 1 (1982) 1-5.

[12] B. Dyson, N. B. Chang, Forecasting Municipal solid waste generation in a fast-grow urban region with system dynamics modeling, *Journal of Waste Management* 25 (2005) 669-973.

[13] W. Fang, H. An, H. Li, X. Gao, X. Sun, Urban Economy Development and Ecological Carrying Capacity: Taking Beijing City as the Case, *Energy Procedia* 105 (2017) 3493-3498.

[14] M. D. Feith, F. Pasiouras, Assessing bank efficiency and performance with operational research and artificial intelligence techniques: A survey, *European Journal of Operational Research* 204 (2010) 189-198.

[15] A. Ford, Modeling the Environment, *Island Press, Washington DC,* (1999).

[16] J. W. Forrester, Industrial Dynamics, *MIT Press, Cambridge, Massachusetts* (1961).

[17] J. W. Forrester, Urban Dynamics, *The MIT Press, Massachusetts,* (1969).

[18] J. W. Forrester, World Dynamics, *Wright-Allen Press, Massachusetts,* (1971)

[19] H. Fukuyama, W. L. Weber, Measuring Japanese bank performance: a dynamic network DEA approach, *Journal of Productivity Analysis* 44 (2015) 249-264.

[20] B. Golony, An interactive MOLP procedure for the extension of DEA to effectiveness analysis, *Journal of Operational Research Society* 39 (1988) 725-34.

[21] W. E. Grand, E. K. Pederson, S. L. Marin, Ecology and Natural Resource Management: System Analysis and Simulation, *Wiley, New York,* (1997).

[22] D. Holod, H. F. Lewis, Resolving the deposit dilemma: A new DEA bank efficiency model, *Journal of Banking and Finance* 35 (2011) 2801-2810.

[23] S. Howick, Using System Dynamics Models with Litigation Audiences, *European Journal of Operation Research* 162 (2005) 239-250.

[24] M. C. Kao, C. T. Lin, L. Xu, Do financial reforms improve the performance of financial holding companies? The case of Taiwan, *International Review of Finance* 12 (2012) 491-509.

[25] E. R. Larson, A. V. Ackere, K. Warren, The growth of service of growth: Using System dynamics to understand service quality and capital allocation, *Decision Support System* 19 (1997) 271-287.

[26] Y. Li, J. L. Hu, H. W. Liu, Non-performing loans and bank efficiencies: an application of the input distance function approach, *Journal of Statistics and Management Systems* 12 (2009) 435-450.

[27] D. L. Meadows, Toward Global Equilibrium, *Collected Papers, Wright-Allen Press, Massachusetts,* (1973).

[28] J. D. W. Morecroft, System Dynamics and Micro world for Policymakers, *European Journal of Operation Research* 35 (1988) 301-320.

[29] A. Mukherjee, R. Roy, System dynamic model of management of a television game show, *Journal of Modeling in Management* 1 (2006) 95-115.

[30] P. Otto, A System dynamics model as a decision aid in evaluating and communicating complex market entry strategies, *Journal of Business Research* 61 (2008) 1173-1181.

[31] W. Qu, G. O. Barney, Projecting China s Grain Supply and Demand Using a New Computer Simulation Model, *Millennium Institute, Arlington, VA,* (1988).

[32] E. B. Robert, Managerial application of System Dynamics, *Pegasus Communications. Waltham M. A.* (1978).

[33] G. P. Randers, Elements of the System Dynamics Method, *Productivity Press, Cambridge,* (1980).

[34] G. P. Richardson, P. Otto, Applications of System Dynamics in marketing: Editorial, *Journal of Business Research* 61 (2008) 1099-1101.

[35] G. P. Richardson, A. L. Pugh, Introduction to System Dynamics Modeling with DYNAMO, *Cambridge, Productivity Press, Massachusetts,* (1980).

[36] M. Ronkko, Hybrid systems: Modeling and analysis using emergent dynamics,*Nonlinear Analysis: Hybrid System* 4 (2007) 560-576.

[37] A. K. Saysel, Y. Barlas, O. Yenigun, Environment sustainability in an agriculture development project: ac system dynamics approach, *Journal of Environment Management* 64 (2002) 247-260.

[38] P. C. Smith, A. V. Ackere, A note on the integration of system dynamics and economic model, *Journal of Economic Dynamic and control* 26 (2002) 1-10.

[39] J. D. Sterman, System Thinking and Modeling for Complex Word. Business Dynamics, *McGraw-Hill, Irwin.*

[40] T. J. Stewart, Goal directed benchmarking for organizational efficiency, *Omega* 38 (2010) 534-539.

[41] Y. Sun, N. Liu, J. Shang, J. Zhang, Sustainable utilization of water resources in China: A system, *Journal of cleaner production* 20 (2017) 613-625.

[42] E. Suryani, S. Y. Chou, C. H. Chen, Air passenger demand forecasting and passenger terminal capacity expansion: A system dynamics framework, *Expert System and Application* 37 (2010) 2324-2339.

[43] E. Thanassoulis, R. G. Dyson, Estiminating preferred target input-output levels using data envelopment analysis, *European journal of Operational Research* 56 (1992) 80-97.

[44] K. Vizayakumar, P. K. J. Mohapatra, Environment impact analysis of a coalfield, *Journal of Environment Management* 34 (1991) 73-93.

[45] T. S. Wood, M. L. Shelley, A Dynamic model of bioavailability of metals in constructed wetland sediments, *Ecological Engineering* 12 (1999) 231-252.

[46] D. Wu, S. Ning, Dynamic assessment of urban economy-environment-energy system using, *Environmental research* 164 (2018) 70-84.

[47] N. H. Yim, S. H. Kim, H. W. Kim, K. Y. Kwank, Knowledge based decision making on higher level strategic concerns: system dynamics, *Expert Systems with Applications* 27 (2004) 143-158.

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