Designing the performance evaluation indicators of Hormozgan Social Security Organization's service supply chain by the Network Data Envelopment Analysis Model

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ABSTRACT

The Social Security Organization is a public and non-governmental institution, and the largest insurance organization in the country. Considering the large number of activities and work processes of the Social Security Organization and in view of the large number of clients of the Organization, it is mandatory to provide a transparent comprehensive performance evaluation of the Organization with two approaches of controlling and monitoring of the Organization performance for the purpose of creating economic and social changes and also gaining client satisfaction. To this end, the present study aims at forecasting and evaluating the performance of branches of Social Security Organization in the future. Network data envelopment analysis (NDEA) technique and System dynamics methodology are used for this purpose. As a case study, the efficiency of 15 social security branches of Hormozgan province is evaluated and forecast, and efficient and inefficient branches are identified. Finally, necessary strategies to eliminate the factors of inefficiency of the branches are examined to increase quality of services and satisfy the clients of the Organization.

Keywords:

Performance Evaluation, Social Security Organization, Network Data Envelopment Analysis Model, System Dynamics.

1. Introduction

In different countries, the Social Security Organization has reached such a high position that it can play key role in social and economic development of these countries through confidence building. In Iran, too, the Social Security Organization forms the main insurance pillar in the private sector, and it is the largest insurance organization. Therefore, one of the requirements of creating change for providing desirable services in the Social Security Organization is to design the key performance indicators of Social Security and implement the performance evaluation system (Papp, 1999). The reason is that the existing gap cannot be identified without determining key performance indicators and, thus, no steps can be taken towards achieving the goals of social security, which, ultimately, seeks to provide welfare for the society (Rojuee et al., 2017). Therefore, various methods have been developed for performance evaluation, among which data envelopment analysis was proposed as an efficient mathematical model in the field of operations research for evaluating the efficiency of organizations (Cook et al., 2016), because it has no presuppositions about performance boundaries. Moreover, its other popularity is due to the presence of multiple inputs and outputs in this model and its suitability for examining nonlinear relationships in analyses (Chang et al., 2011). On the other hand, conventional models of data envelopment analysis for evaluating the efficiency of organizations ignore the relationship between activities or internal activities and are not able to deal with organizations with a multi-segment service nature, which is why network data envelopment analysis (NDEA) models emerged to measure partial efficiency as well as total efficiency in a single integrated framework. This model means that the efficiency of all decision-making units is considered as the overall goal, and the efficiency of the segments form its components (Tone and Tsutsui, 2009). In this model, the purpose is determining the efficiency of the main decision-making unit as well as sub-decision making units or sub-units (Sexton and Lewis, 2003), because if the performance of sub-units is not taken into account in measuring the performance, an apparent estimate of performance quality has been actually made. This is particularly true about the performance of the Social Security Organization which, like many organizations, is a multi-step process, and traditional models of data envelopment analysis could not have a comprehensive assessment of the performance of the organization because they do not pay attention to these steps in evaluation due to their black box view. Hence, network data envelopment analysis is used in this study to eradicate this flaw. In general, despite its many capabilities addressed by various researchers, data envelopment analysis method also has substantial flaws. One of the most significant flaws is that it relies on the data of time periods that the units under investigation have already gone by. Therefore, the findings that this model provides to the manager as a solution is are based on old information. Meanwhile, considering the dynamics of environmental factors, no desirable outcome may be reached by extending the findings of some old data to decide about a future time period (Saremi and Khoeini, 2004). In fact, since data envelopment analysis models use present-time input and output for performance evaluation, the results obtained from evaluations are not suitable for future time, and, thus, organization managers are not able to plan for future and improve the activities of their sub-units on the basis of these results. One way to solve the abovementioned problem is to use the System Dynamics methodology developed by the Massachusetts Institute of Technology (MIT) in 1950s (Forrester, 1961). One can claim that system dynamics is one of the most effective tools which provides the opportunity to identify and understand the rules governing the changes in complicated systems (Sushil, 2014). Therefore, and specifically, the aim of this study is to design a performance evaluation system to modify network data envelopment analysis methods, and combine it with the system dynamics simulation model for performance evaluation of 15 branches of Hormozgan Social Security Organization in the future. In this line, the study opts for identifying efficient and inefficient branches, and drafting appropriate strategies to improve the performance of inefficient branches and enhance efficient branches.

2. Literature Review

Performance evaluation system can be accounted for as an assessment and measurement process, and comparison of amount and manner of obtaining a desirable state. In fact, performance evaluation is the process of development and applying measurable indicators which allow a systematic evaluation of the amount of predetermined progresses (Rafizadeh et. al., 2013). Moreover, performance evaluation computational methods fall into two categories of parametric and non-parametric methods. Parametric method requires a mathematical function based on which dependent variables are estimated by employing independent variables. In addition to that, hypotheses about data distribution function as well as model limitations should also be taken into consideration. However, non-parametric methods do not require to know the statistical properties of the production function. Conversely, all available units are compared against each other in this method and more successful units are identified using the linear programming mechanism. Data envelopment analysis technique is one of the non-parametric methods to measure efficiency and does not require to obtain the distribution function and make hypotheses about it. This method generally makes a virtual unit with highest efficiency by combining all units under investigation, and measures inefficient units against that (Mehregan, 2016). Considering that nowadays, many of production and service processes depend on one another, these dependencies should be analyzed by employing scientific techniques. Two-stage data envelopment analysis technique is a notion that can analyze these relations and dependencies. The approach of network data envelopment analysis model is in fact two-stage data envelopment analysis model. At the onset, a DEA model is formed and solved for each decision-making unit to measure its efficiency (Prieto and Zofio, 2007). Since data analysis models work based on historical information, their greatest weakness is that they measure performance of decision-making units in the past. These models do not offer a framework for future, which is why system dynamics simulation model is used to overcome this shortcoming. This method forecasts system behavior by considering the relations between system components. These models provide a way to identify and understand the behavior of complicated systems over time. What distinguishes system dynamics method from other methods is that it employs feedback loops and flow and state variables which help to understand system behavior. The rational of this system is that identification of system structure, nonlinear relations, delays and feedbacks in determining system behavior are as crucial as identification of each of system components (Sterman, 2018). In Table (1) the most important research that directly relates to identifying is presented.

Table 1. Research Background

Tan et al. (2017)	They have evaluated have evaluated service performance in the automobile industry, using DEA and BSC, with the help of four pillars of customers, finance, internal business processes, and learning and growth
Grosser (2005)	He has modelled the dynamics of Germany health insurance system, and has focused on its investment fund to simulate and analyze different policies to improve the condition of the afore-mentioned fund.
Franco (2005)	He has viewed insurance companies from the perspective of information flow and has endeavored to provide a model to manage the loss coefficient in insurance companies.
davoodi and Forutanchehr (2019)	They have provided a dynamic analysis of ordering system in supply chain with a system dynamics approach.
Hosseinzadeh Saljooghi and Rahimi (2019)	They evaluated the performance of supply chain management of Iranian resin industry by network DEA model using fuzzy data.
Rezaei Pandari and Azar (2018)	They proposed a model for managing the service supply chain in the insurance industry using a systematic plan of grounded theory. The proposed model can form the basis of designing models for performance and promotion evaluation of service companies.

3. Method

The research method used in this research is essentially of applied type. Due to the fact that the system dynamics model and the theoretical findings of the network data envelopment analysis model are used in practice in the real conditions of the Social Security Organization of Hormozgan province to show the efficiency, therefore, the present study is a case and field research. The statistical population of this study includes 15 branches of the Social Security Organization of Hormozgan province, namely Lengeh, Bastak, Parsian, Sirik, Abu Musa, Bandar Abbas 1, Bandar Abbas 2, Bandar Abbas 3, Jask, Qeshm, Haji Abad, Minab, Roudan and Kish, which were active in the Social Security Organization of Hormozgan province during the time the research was underway in 2018. Considering that the whole statistical population has been studied and evaluated in this research, no sampling was performed in this research. System dynamics and network data envelopment analysis methods are used to analyze data. This study is conducted a theoretical-field research to collect information and identify the indicators impacting the model efficiency, and also detect different components and aspects of the model. Theoretical data and principles related to system dynamics model and network data envelopment analysis model are collected through library study and paper reviews. Finally, the data for evaluation of Hormozgan social security branches are gathered from Organization documentations. Figure (1) demonstrates the research stages:

The research stages will be explained in what follows:
It is necessary in any applied research to study and identify effective parameters in the field of research. For this end, in order to identify and extract effective input and output indicators and an intermediate to evaluate the relative efficiency of social security branches, an extensive field and library study was carried out on variables and indicators available in the field of research. After reviewing and reading the articles, a guided interview was conducted with competent authorities of Hormozgan province Social Security Organization to fully understand all research indicators. Ultimately, final indicators were specified in the form of a state-flow diagram, as illustrated in Figure 2:

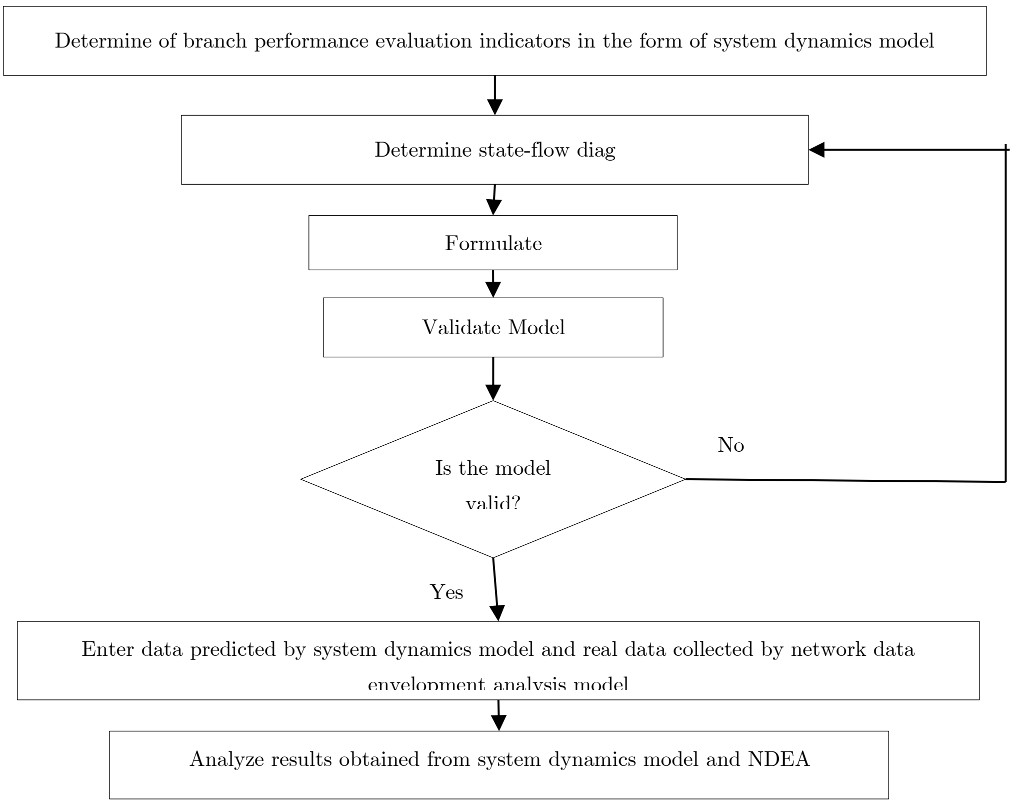

Figure 1. Steps of conducting research

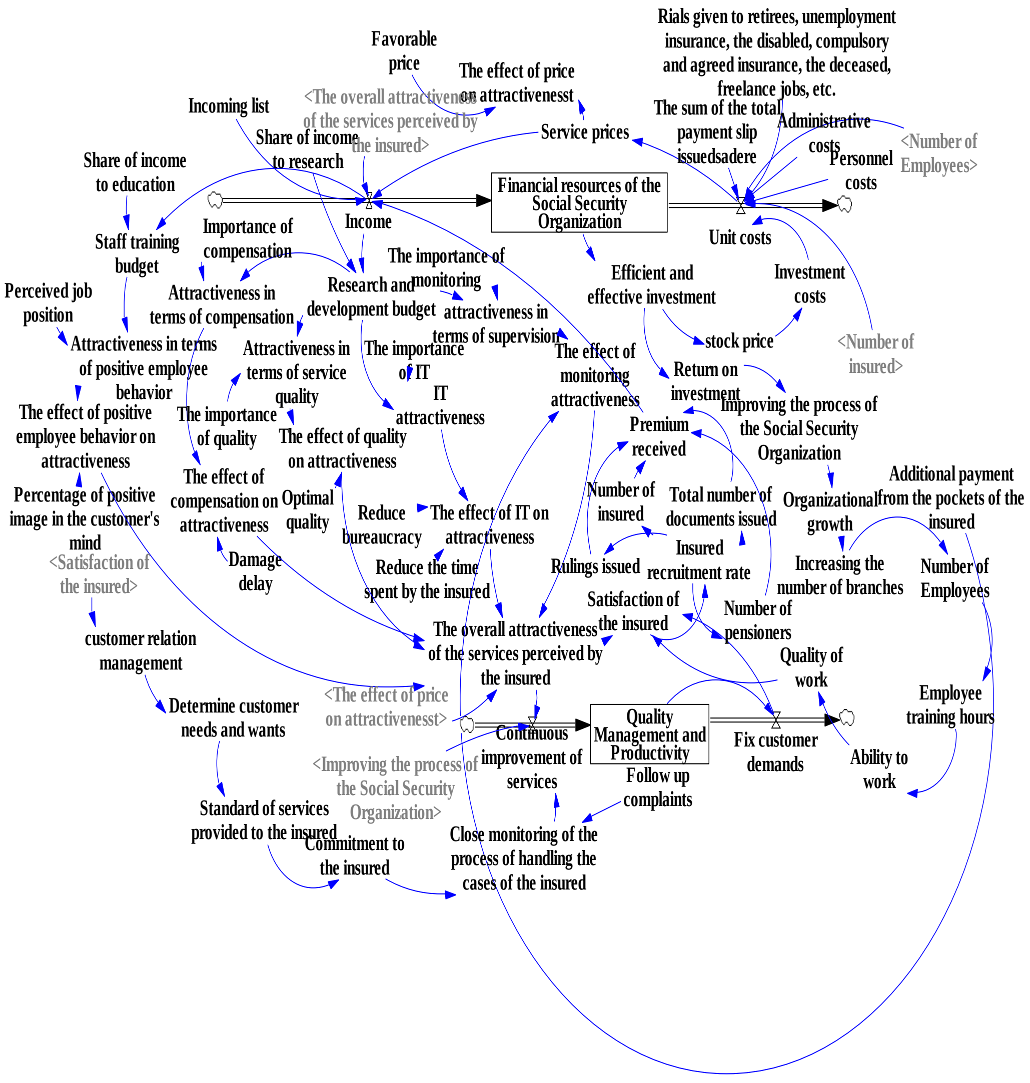

Figure 2. Performance evaluation indicators in the form of state-flow diagrams

This diagram has 2 state variables, 4 flow variables, and 58 auxiliary variables (intermediate and table). State variables include: financial resources of the Social Security Organization, and quality management and productivity. Flow variables consist of income, unit costs, continuous improvement of services, and fixing customer demands. Other variables present in the model form auxiliary variables. In order to execute the state-flow diagram, it is necessary to allocate a mathematical formula to each of the variables, as described below:

Financial resources of the Social Security Organization- Income integral-Unit costs

Quality management and productivity-Continuous improvement of services integral-Fixing demands of the insured

Income-Total sum of service price, received insurance contribution, Incoming list, overall attractiveness of services perceived by the insured

Unit costs-overall sum (investment costs, administrative costs, personnel costs, and total sum of the issued sheet) plus (total number of the insured and number of personnel) divided by Rials given to retiree services (the disabled, the deceased, survivors, unemployment insurance, agreed and compulsory insurance, and freelance insurance)

Continuous improvement of services-Overall improvement of Social Security Organization processes, and overall attractiveness of services perceived by the insured-monitoring and reviewing the files of the insured

Fixing the needs of the insured-linear ascending function of quality management and productivity

Moreover, the effect of the research and development budget and personnel training budget on product features are considered as table functions. (Lookup)Table functions are used for other overall attractiveness of the product, including IT attractiveness, price, proper personnel behavior, monitoring and inspecting damage payment, and service quality. Auxiliary variables are employed to explain the notions of the real world more clearly and facilitate the equations. A variable can be defined based on causal variables by using some of the auxiliary variables in the form of a lookup function. However, if it is not possible to write the certain function, mathematical functions are used to demonstrate them and some other variables are given in the range to that number.

Two methods of structure validation and behavior validation are used in this study. Opinions of experts with employment record in the Social Security Organization are used to perform the first validation. Cause and effect structure of the model and table functions used in the model and also the simulated behavior were approved by the experts. In order to perform the second validation, some simulation with sudden severe changes in some model parameters to examine the validity of the model's reaction to these changes. For instance, if the base price of services drops greatly, the model should show a higher attractiveness for service prices, and impact the total number of the insured. For this purpose, the price was reduced from 50 to 20 and its impact is shown in Figure 3.

As illustrated in Figure (1), the base state is shown by the red curve and price attractiveness is shown by the blue curve. The total number of the insured has increased from 75000 individuals to 225000 individuals as a result of price reduction, approving the validity of the model .

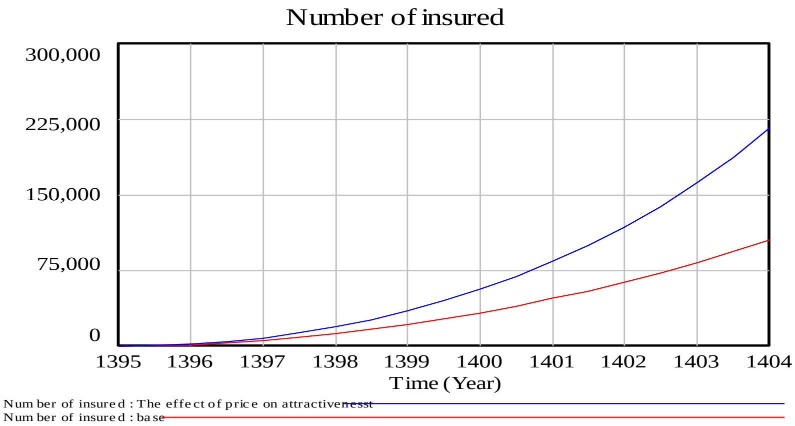

Figure 3. Analysis of sensitivity to decrease of base service price

After conducting the sensitivity and policy analysis, a valid model with an improved political structure is yielded which can be used to forecast the performance evaluation of 15 branches of the Social Security Organization in the future. Moreover, after the performance evaluation indicators of Hormozgan province Social Security Organization are determined in the form of stat-flow diagram, there is a need to rank the branches of this Organization in terms of efficiency. Thus, the network data envelopment analysis method was employed to rank the indicators. For this end, the required input and output indicators were determined. As stated earlier, final indicators are specified in the form of state-flow diagram. However, since the vastness of activities of the Social Security Organization yields multiple indicators, the most significant indicators effective in efficiency evaluation were selected based on the opinions of experts and managers of the Social Security Organization about the significance of the state-flow diagram. As demonstrated in Table (2), the indicators entered the network data envelopment analysis.

After determining the indicators for performance evaluation of branches of the Social Security Organization and beginning to forecast the amount of indicators in the future through system dynamics, it is essential to evaluate the effectiveness of branches, as well. Therefore, network data envelopment analysis (NDEA) was employed.

The network structure obtained according to Shafiee model (2017) was presented to the authorities of the Social Security Organization of Hormozgan province and was used to build the model after its approval. The input and output of the model are demonstrated in Table 3:

Table 2. Indicators effective on evaluating the service supply chain performance of the research

Input Indicators	Intermediate Indicators	Output Indicators
No. of (common) personnel	Total No. of the insured	Sums paid to the insured in IRR
No. of hours to train personnel	Total No. of pensioners	Sums of the issued payment sheet
Office charges	No. of (common) personnel	Issued Orders
Personnel costs		Issued Documents
Income list		

Table 3. Input and Output Indicators of First and Second Levels

First Level Input	Notation	First Level Output	Notation
(Common) Personnel	x^1	Issued Orders	y^{11}
Personnel Training Hours	x^{D11}	Issued Documents	y^{12}
Office Charges	x^{D12}	Total Pensioners	y^{I11}
Personnel Costs	x^{D13}	Total Insured Persons	y^{I12}
Second Level Input	**Notation**	**Second Level Output**	**Notation**
(Common Personnel)	x^2	Sum of Issued Payment Sheet	Y^{21}
Total Pensioners	y^{I11}	Sums in IRR paid to Insured Persons	Y^{22}
Total Insured Persons	y^{I12}		
Income List	x^{D2}		

Hence, the mathematical form of the conceptual model presented above to evaluate the performance of the branches of Hormozgan Social Security Organization will be as follows:

$$\text{Min} C^{2^I}\bar{X}^{D_{11}} + C^{3^I}\bar{X}^{D_{12}} + C^{4^I}\bar{X}^{D_{13}} + D^{1^I}\bar{X}^{D_2} + D^{2^I}\bar{y}^{I_{11}} + D^{3^I}\bar{y}^{I_{12}} + C^{1^I}E$$

$$\text{Min-} C^{1^I}\bar{X}^1 + D^{1^I}\bar{X}^{D_2} + D^{2^I}\bar{y}^{I_{11}} + D^{3^I}\bar{y}^{I_{12}} + C^{1^I}E$$

s.t1:
s.t2:

$$\sum_{j=1}^{n} \lambda_j X_j{}^1 \le \overline{X^1} \qquad \sum_{j=1}^{n} \Pi_j X_j{}^2 \le E - \overline{X^1}$$

$$\sum_{j=1}^{n} \lambda_j X_j{}^{D_{11}} \le \overline{X^{D_{11}}} \qquad \sum_{j=1}^{n} \Pi_j X_j{}^{D^2} \le \overline{X^{D^2}}$$

$$\sum_{j=1}^{n} \lambda_j X_j{}^{D_{12}} \le \overline{X^{D_{12}}} \sum_{j=1}^{n} \lambda_j X_j{}^{D_{13}} \le \overline{X^{D_{13}}} \qquad \sum_{j=1}^{n} \Pi_j Y_j{}^{I^{11}} \le \overline{Y^{I^{11}}}$$

$$\sum_{j=1}^{n} \lambda_j Y_j{}^{11} \ge Y_o{}^{11} \qquad \sum_{j=1}^{n} \Pi_j Y_j{}^{I^{12}} \le \overline{Y^{I^{12}}}$$

$$\sum_{j=1}^{n} \lambda_j Y_j^{12} \geq Y_o^{12} \qquad \sum_{j=1}^{n} \Pi_j Y_j^{I^{21}} \geq Y_o^{I^{21}}$$

$$\sum_{j=1}^{n} \lambda_j Y_j^{I^{11}} \geq Y_o^{I^{11}} \qquad \sum_{j=1}^{n} \Pi_j Y_j^{I^{22}} \geq Y_o^{I^{22}}$$

$$\sum_{j=1}^{n} \lambda_j Y_j^{I^{12}} \geq Y_o^{I^{12}}$$

$$\overline{X^1}, \overline{X^2}, \overline{X^{D^{11}}}, \overline{X^{D^{12}}}, \overline{X^{D^{13}}}, \overline{X^{D^2}}, \overline{Y^{I^{11}}}, \overline{Y^{I^{12}}}, \lambda_j, \Pi_j \geq 0$$

4. Findings

Given that data envelopment analysis models consider that past and the present, i.e. they yield the amounts of efficiency evaluation based on past data, the present state of the unit under investigation is evaluated in comparison to the state of other units in the future to overcome the said weakness of data envelopment analysis models. That is, real data is used to evaluate the unit under investigation and simulated data obtained from system dynamics model in used for other units. So the following results, tabulated in Table (4) were obtained when the data of the network data envelopment analysis model was entered in winQsb:

As shown in Table (4), service chain efficiency is calculated for the 2018 year at level 1, level 2 and in total. The branches with an efficiency score of one (1) are efficient and branches with an efficiency score below one are inefficient. According to the Table, 12 branches are efficient and only three branches are considered inefficient. In fact, Lengeh, Bastak, Parsian, Bandar Abbas 1, Bandar Abbas 2, Bandar Abbas 3, Jask, Qeshm, Haji Abad, Minab, Roudan and Kish are efficient because they obtained Rank 1, and Sirik, Abu Musa and Lavan branches are ranked below one, so they are inefficient.

Moreover, it can be generally stated that since an efficient unit has an efficiency score of 100, therefore, based on this definition, 12 branches, i.e. 80% of the branches, are efficient, and 3 branches, i.e. 20% of the branches, are ineffective. Other statistical findings are as follows:

Efficiency of 80% of branches is above 95% .
Efficiency of 80% of branches is above 90% .
Efficiency of 86.66% of branches is above 75% .
Efficiency of 86.66% of branches is above 50% .
Efficiency of 13.33% of branches is below 50% and also below 25% .

Moreover, efficient branches can serve as an efficient unit and a reference for others branches. In fact, inefficient branches can look upon efficient reference branches and become efficient. For this purpose, reference sets are shown in Table 5 for each of the first and second levels of the service supply chain and for each of the branches, along with the optimal values of each branch.

Table 4. Results of efficiency scores of branches

Branch	Unit evaluated in t period and other units evaluated in t+1 period		
	Efficiency Level 1	Efficiency Level 2	Total Efficiency
Lengeh	1	1	1
Bastak	1	1	1
Parsian	1	1	1
Sirik	.7704	.7335	.8053
AbuMusa	1	1	1
Bandar Abbas 1	0.6018	1	0.2037
Bandar Abbas 2	1	1	1
Bandar Abbas 3	1	1	1
Jask	1	1	1
Qeshm	0.6788	0.3577	1
Haji Abad	1	1	1
Minab	1	1	1
Roudan	1	1	1
Lavan	0.6180	1	0.2360
Kish	0.8889	0.7778	1

Table 5. Efficient (Reference) and Inefficient Branch Analysis

Inefficient Branch	1st Level Reference Set	λ Value	2nd Level Reference Set	Π Value
Sirik	Bandar Abbas 1, Haji Abad, Kish	0.0101 0.0082 0.0781	Lengeh, Bandar Abbas 3, Minab	0.0183 0.0587 0.0074
Abu Musa	Haji Abad, Kish	0.0159 0.0164	Abu Musa	1
Lavan	Bandar Abbas 1, Haji Abad, Kish	0.0024 0.0272 0.0914	Lavan	1

As shown in Table 5, the optimal values of the reference branches indicate the share of each the reference branches in improving the efficiency of inefficient branches at each level. Table 5 can also be used to rank the efficient units of each level. That is, among the efficient branches, the branch that has the most repetition among the reference branches for inefficient branches, as a reference, obtains a higher rank. Therefore, among the efficient branches at level 1, Haji Abad and Kish branches have a higher rank among the level 1 branches, because they are selected as the reference unit for inefficient units with three repetitions, but the branches of the efficient at level 2 all have the same rank.

5. Discussion and Conclusions

The Social Security Organization is the main pillar of insurance in the private sector and the largest insurance organization. Considering the large number of users of social security services, it is of crucial importance to design key indicators of social security performance evaluation, because the existing gap cannot be identified without determining key performance indicators and, thus, no steps can be taken towards achieving the goals. Therefore, this article focuses on the design of indicators and a comprehensive suitable model to evaluate the performance of the branches of the Social Security Organization of Hormozgan province. Various techniques are proposed for performance evaluation, including the mathematical model of data envelopment analysis which uses input-output analysis to evaluate efficiency of decision-making units. On the one hand, it was essential to propose a model for performance evaluation which is able to focus on the interactions of input, intermediate, and output data among branch levels according to the nature of the branches of the Social Security Organization, and at the same time, solve a mathematical model to evaluate the performance of the entire branch and its levels. Therefore, the network data envelopment analysis model was used in this study. On the other hand, data envelopment analysis models are not able to provide a suitable model for the future, therefore, managers will not be able to plan for future and improve activities of their sub-units by employing the results obtained from this method. A new approach was adopted to overcome the above-stated problem. The system dynamics method was employed and the behavior of branches of the Social Security Organization in 2018 was forecast by modeling the behavior of the Social Security Organization, drawing relations among its variables, and making equations to show the relations among the variables. Then, having obtained the predicted data of variables in the future, the performance evaluation of the effi of the Social Security Organization was performed using the network data envelopment analysis technique. That is, the branch under evaluation was kept in its present state and other branches were taken into the future; and performance of 15 branches of the Social Security Organization of Hormozgan province was evaluated against the predicted performance of other units in the future. Ultimately, efficient and inefficient branches were identified, and performance improvement strategies were proposed to escalate the performance of inefficient branches to border of efficiency. Moreover, the result of this study showed that the proposed model is suitable for evaluating the branch performance because this model has the ability to account for interactions of component of the branches of the Social Security Organization, and the ranking results have a large analytical power. Further, measuring the efficiency score and, thus, identifying efficient and inefficient branches leads to more knowledge for managers about the performance of the branches. Elimination of the factors of inefficiency of the branches results in quantitative and qualitative growth, and customer satisfaction in the Organization. Hence, it is suggested that the performance of the Social Security Organization of Hormozgan province be measured annually based on the model mentioned in the present study, so that due measures may be adopted to evaluate the performance and revise the Social Security Organization to achieve efficiency at an optimal level. In addition, the following suggestions are presented for future research :

1) This model may be used to evaluate the efficiency of similar units and other organizations of Social Security; and
2) Other methods may be used to evaluate the service supply chain performance and compare results with those of the present research.

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