Applications of Data Envelope Analysis Using Efficient or Inefficient Frontiers in Evaluating the Efficiency of Rural Healthcare Centers (Case Study: Langroud County)

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Abstract

Objective: This study was conducted to examine the efficiency of rural healthcare centers (Health Houses) including output-oriented efficiency, input-oriented efficiency, optimistic efficiency, pessimistic efficiency and efficiency range in Langerud County in Guilan province.

Method: This study is a descriptive-analytical one whose data is cross-sectional collected through field works in 2016 from 45 rural healthcare centers in Langerud County. The required data were obtained from available documents and statistics, and were analyzed using Windeap and GAMS software packages. In this paper, to evaluate the performance of rural healthcare centers from March 2015 to March 2016, two inputs and three outputs were determined. The input included the costs and the number of health workers, and the outputs included family health clients, outpatients, and the clients who needed wound dressings.

Findings: The results showed that nine out of 45 rural healthcare centers, with an efficiency score of 1, have efficient performance. Rural healthcare centers in villages of Garask, Koru Roud Khaneh, and Malat are respectively the first three villages with the highest efficiency score. The study results showed that the average optimistic efficiency at output-oriented and input-oriented efficiencies are 1.645 and 0.688, respectively, and 15.5% of rural healthcare centers are pessimistically inefficient. Besides, 64% of the units are between the efficient and inefficient frontiers, and are not pessimistically inefficient; meanwhile, those units are not on pessimistic lines of efficiency which demonstrates indulgence in input consumption or a potential ability in increased offered services or decreased input consumption. According to the results, maximum optimistic efficiency is 3.87 and its minimum is one. Maximum pessimistic efficiency is one and its minimum is 0.29.

Practical Implications: As the results show, it is suggested that efficient healthcare units be used as paragons and that assessing educational requirements of inefficient rural healthcare centers would provide useful information for planners and policy makers.

Key words: Optimistic efficiency, Pessimistic efficiency, Efficiency range, Health.

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1. Introduction
1. 1. Statement of the Problem

Given the importance of measuring the development of healthcare system and its impact on increasing labor productivity and production in agriculture, the efficient allocation of resources in this area and consequently assessing the performance of healthcare centers, which are the main operating units of the healthcare sector in rural areas are very important. The healthcare sector in many countries is facing severe resource constraints; therefore, productivity and efficiency and appropriate use of the facilities are of particular importance. Health Houses as the most convenient and accessible health units of a county located in rural areas are the symbol of the development in primary healthcare system and have had valuable effects on improving health indicators (WHO, 2000). These centers are established to provide villagers with more primary healthcare. As the eradication of rural poverty is one of the goals of the Islamic Revolution, such centers are established in rural areas to partially fulfill that promise.

The role of the service sector is growing in many countries, especially in developing countries. This is due to the public demand for services in line with favorable social standards. The growing importance of this sector and the rising expectations of people from the governments to increase the efficiency and effectiveness on the one hand, and the staggering costs of administration of the service sector are very important in terms of socio-economic development and distribution of facilities. In developing countries, the lack of efficiency and effectiveness of services not only reduces the quality and standards of living, but it also hinders productivity improvement in other sectors of the economy, which increases social injustice and inequality, and political issues (Tourani, 2005).

Equitable access to basic health services, with a minimum of quality and affordable price, is the inalienable right of every citizen in any country, and the governments are obliged to provide these services to their citizens in a fair way (Tourani, 2011). Studies on health disparities show that the gap in health status between the poor and the rich is growing (Asaee, 2001). Increased efficiency and effectiveness of health services, justice,

sustainable financing, and competent management of health sectors are among the objectives of reform in healthcare sector (Mastaneh & Mouseli, 2011). However, the promotion of public health is one of the main objectives of the plans implemented in the Islamic Republic of Iran. Article 29 of the Constitution of the Islamic Republic of Iran declares health and treatment are fundamental rights of all people; accordingly, the health policies of the country designated by the Ministry of Health and Medical Education are designed to take coordinated measures at various levels of public health through the healthcare networks (Taban, 2001). In a health system, it is essential to measure and evaluate the performance so that one can monitor the efficiency and identify the gaps and inefficient units, and take measures to improve efficiency (Mehregan, 2004). Thus, one aspect of the manifestation of the health services management in a country is to provide services for various segments of the society (Sadeghi Bazargani, Arshi, Mortezazadeh, Bashiri, AminiSani, & Sezavar, 2005). Accordingly, special attention is paid to development of the healthcare sector in Iran. The overall goals of the healthcare sector in the Fourth Development Plan include improving the health of people, meeting the needs that are directly or indirectly related to health, and promoting financial justice in paying healthcare costs (Iran's Economic Reports, 2004). Besides, healthcare indicators are among the most important indicators of development in a country, and the success of national development plans to some extent depends on the fulfilment of the objectives in this sector. If the quality of healthcare indicators in a society is high, and the spatial distribution of these indicators is more balanced and appropriate, there will be relative prosperity and health in that community (Abolhallaji, Mousavi, Anjomshoa, Nasiri, Seyedin, & Sadeghifar, 2014; Nastaran, 2001).

Measurement and evaluation serve as one of the most fundamental basis of science in various fields of human achievements. Performance measurement acts as a beacon guiding all administrative activities; hence, the growth and development of organizations and institutions of the country and consequently the growth of the national economy are the results of assessment, measurement, analysis, comparison, and taking

essential measures in that field. The importance of daily performance measurement is significantly growing. Measuring the performance of the organizations, processes, departments and the staff is so important that one of the main duties and responsibilities of the managers in any organization is to measure the efficiency. Performance evaluation is conducted to determine the compliance of a plan with a specific course and uncover its weaknesses and strengths. The results of the assessment can provide managers and executives with a clear picture of the activities so that managers can make informed decisions necessary to strengthen reform or continue the plans (Tolouei, 2011).

Provision of health services to promote, protect and ensure the health of people is one of the most important principles of progress in any society. Articles 3, 29 and 43 of the Constitution of the Islamic Republic of Iran stress the necessity of providing healthcare as the basic need of the people, because public health is a means for human evolution (Hosseini Nike, 1999).

Healthcare and security are among the basic rights of every person in a community. Health services in a community are directly related to the health and development of the community. People in different age groups have various health needs, and those needs are met in the framework of health services and health centers. Evaluation of satisfaction of recipients of services is one of the important factors to measure efficiency, particularly in healthcare sector. Measuring the level of satisfaction plays a very important role in planning and reforming the health services.

Currently, 29% of the country's populations live in rural areas. Without rural development, the development of health indicators is not feasible. Besides, given the changing needs, the role of Health Houses is quite effective and essential (Nikeniyaz, 2003).

Health promotion is the primary goal of a health system, but it is not the only one. Accessibility and the minimum difference in accessing the health services or in other words, the fairness of the system is very important. In other words, a health system should respond properly to what people expect (Parsay, 2003). Efficient Health Houses in deprived villages help to promote the health of the villagers, and they do not have to go to cities for basic medical treatment. In fact,

countries should work to improve the efficiency of their health systems by creating sound research tools. In this context, the main question in this research is to determine the percentage of efficient rural health centers (Health Houses) in Langerud County, Guilan province.

1. 2. Theoretical Framework

There are two main methods for performance evaluation and measurement of technical efficiency: parametric method and nonparametric method.

Parametric methods are the methods in which, at first, a special production function is presumed, then, with a method commonly used for estimating the functions in econometrics, the indefinite coefficients (parameters) of this function are estimated, the most important of which are the stochastic frontier production function and profit function (Bagherzadeh, 2010).

Nonparametric methods do not need to know the statistical characteristics of the production function, instead in this method, all available units are compared, and using mathematical programming mechanisms, the most successful units are identified (Fortuna, 2000; Mehregan, 2008).

Given the importance of measuring the efficiency of health centers, various studies have examined this subject in Iran and abroad. Zareai (2000) studied the potential capabilities of using Data Envelopment Analysis method (DEA) in hospitals of Tehran University of Medical Sciences. In this study, he examined the efficiency of 57 hospitals. The results showed that out of 57 hospitals, 29 hospitals were fully efficient (efficiency equal to 1), 8 hospitals had efficiency between 1-0.9, 11 hospitals had efficiency between 0.8-0.9, and the remaining hospitals had an efficiency between 0.6-0.8. The researchers concluded that although Data Envelopment Analysis (DEA) is changing and developing, it uncovers the weakness of the current methods of assessing the efficiency of healthcare centers. The results show that the DEA is a simple and useful tool to assess the efficiency of the healthcare centers. Pourreza (2009) proposes a suitable framework for measuring the efficiency of hospitals. In this study, efficiency was measured using two techniques (i.e., simple and DEA). The results showed that 22 out of 53 hospitals were efficient, and the average score of inefficient hospitals was 78 percent. This indicates

that the potential average reduction of 22% of input consumption is possible without affecting the output. Kermani (2009) in a study titled *The Efficiency of Islamic Countries in the Health and Education Sectors Using Data Envelop Analysis (DEA)* showed the efficiency of health systems in most countries in 2005 has significantly declined compared to 2000. In Iran, the efficiency of the healthcare and medical education in 2005 compared to 2000 had significantly declined. Najarzadeh, Torabipoor, Ghasemzadeh, and Salehi, (2012), in a study titled *Assessment of Hospitals Efficiency by DEA in Ahvaz in 2006-2010* showed that the average technical efficiency of the educational hospitals was 0.557 while it was 0.873 for the none-educational hospitals. At hospitals with efficiency less than one, there is a surplus amount of the inputs or outputs; therefore, managers should consider the coefficients of the hospitals and decrease the amount of hospital inputs until they reach the favorable level of efficiency. Inputs include the number of physicians, nurses, and active beds, and outputs include the number of days beds are occupied, number of operations, the number of outpatients and inpatients, and the average length of hospitalization for every inpatient. Shojja (2014) in a paper titled *Firoozkooh Health House Performance Evaluation Using Data Envelopment Analysis,* by CCR model showed that, five out of 18 Health Houses with an efficiency score of one are efficient, and then, he ranked the units with the help of AP-CCR and based on their efficiency. Health Houses in Arjmand, Jeliz Jand, and Mazdaran have respectively gained the first top scores. In this model, inputs included the costs and the number of health workers and the outputs included family health clients, outpatients and clients who needed wound dressings. Thanaann, Chulaporn and Supon (2008) examined the technical efficiency of pharmacological services of hospitals in Thailand using DEA approach and identified the factors affecting their efficiency. The model input indicators include the number of medications, doctors and their support and the output indicators include the distribution of drugs, medicine, inventory control, patient-centered activities and support services provided for the clients. Finally, they found that efficient healthcare centers comprise 19% of the total population. Marshall and Flessa (2008) in their

study titled *Assessing the Efficiency of Rural Health Centers in Burkina Faso: An Application of Data Envelopment Analysis* concluded that 14 out of 20 rural health centers had a technical efficiency equal to one, and four out of six rural health centers had a technical efficiency less than 50 percent. Ancarani (2009) presented a model in the healthcare sector that shows the relationship between decision-making and technical efficiency. In his research, at first using the DEA, the technical efficiency of large hospitals in Italy were calculated, then, based on management policies and environmental variables, the institutions were compared. Finally, it became clear that management decisions on the use of resources compared to external factors have a greater impact on the efficiency of the health sector. Using health indicators and the proportion of health spending to GDP, Alin and Marita (2011) employed DEA and analyzed the economic efficiency of health systems in Europe and concluded that the average efficiency of health spending in the EU was less than one, and most of their units are inefficient, i.e., their benefits are less than their costs. Leleu (2014) examined the efficiency of hospitals in Florida using Data Envelopment Analysis. For this purpose, 138 hospitals were evaluated. The inputs included the number of hospital beds, the number of full-time medical staff and other hospital staff. The outputs entered in the model included hospital income and the number of hospitalization days. The results showed that inefficient hospitals on average had 41 percent of medical staff, 29 percent of other hospital staff and 33 percent of hospital beds. On average, if the inefficient hospitals increase their efficiency, they can reduce costs up to 18 percent. Nattinger, Mueller, Ullrich, and Zhu, (2016) examined the financial performance of rural health service provider in the USA. The results showed that less than 10% of the units have been financially efficient. Further, there is no relationship between the size of these units and their work experience, and their financial performance. Mohammadi, Karami, Bayat, Esfandnia, Kazemi, Bayati, and Esfandnia, (2015) examined the technical efficiency of medical sciences hospitals in Kermanshah province using DEA. For data analysis Windeap and GAMS software packages were used. The output of this model included the number of

admissions to hospital, hospital bed occupancy rate, duration of hospitalization, the number of outpatient treatments, and the inputs to the model include the number of physicians, number of nurses, hospital beds and number of employees. The results showed that 62 percent of the hospitals were efficient and the remaining 38% were inefficient. The average efficiency score of inefficient hospitals was 81 percent. Most researchers used classical or conventional data envelopment analysis to evaluate the efficiency. This method calculated the efficiency only from the optimistic view, in which the efficiency frontier is created by a convex combination of efficient units. Therefore, any firm that lies on the efficiency frontier would be efficient, otherwise it is inefficient. As in this method, the efficiency is calculated only from the optimistic perspective, and a precise and definite number is provided as the efficiency of a unit, it is unable to provide a comprehensive assessment of efficiency. Since in a bounded DEA, the efficiency of units is measured in a range between the lower and upper limits, a more comprehensive assessment of the efficiency of the unit is provided. Therefore, in this study, this method is used for evaluating the efficiency of the Health Houses in Langerud County which serve as units promoting the health and safety of people.

Figure 1. Geographical Location of Langerud County, Guilan Province.

2. Research Methodology

2. 1. The Study Area

Langerud is one of counties of Guilan province, with an area of about 438 square kilometers, located in Eastern Guilan. It is 60 kilometers far from the provincial capital. Langerud borders the Caspian Sea in the north, Amlash in the south, Lahijan and Siahkal in the west, and Rudsar in the east. Langarud County consists of 3 districts (i.e., Central, Komala, Otaguor), five towns (i.e., Langerud, Komala, Otaguor, Shellman, Chaf and Chamkhaleh), 195 villages and 7 rural districts (Dehestan). Langerud County has a population of over 137,272, out of which 92037 are urban population, and 45235 are rural population. 84 percent of the populations are literate (Statistical Center of Iran, 2011).

2. 2. Research Methodology

Nonparametric data envelopment analysis method dates back to Farrell (1957) and later developed by the Charnes, Cooper, and Rhodes, in 1978. In this method, linear programming is used and there is not any consequential basic assumption about the relationship between inputs and outputs (Mojarrad, Kaikha, and Sabuhi-Sabuni, 2009). Since the DEA covers all the data and information, it is regarded as a comprehensive analysis of the data (Moazeni & Karbasi, 2008). The general pattern of linear programming model for measuring efficiency is the same as model 1.0 (Aziz & Jahed, 2011)

$$\text{Min } \theta = \frac{\sum_{i=1}^{m} v_i x_{ij}}{\sum_{r=1}^{s} u_r y_{rj}} \tag{1}$$

s.t

$$\frac{\sum_{i=1}^{m} v_i \, x_{ij}}{\sum_{r=1}^{s} u_r y_{rj}} \geq 1$$

$u_r, v_i \geq 0$

$(j = 1,2,3,\dots,n)$,
(r = 1,2,3,…,s),
(I =1,2,3,…,m)

Where u is the weight of output, and v includes the weight of inputs, y represents the outputs and x represents the inputs. The above relation is a convex nonlinear relationship model that has a myriad of optimal solutions. To solve this problem, using a linear transformation, the model can be converted to a linear one. For this purpose, the denominator is taken as equal to a constant default value of one, and the denominator is minimized, and it is called DEA input-oriented model, or the denominator is presumed as equal to zero, and the denominator is minimized, this model is called output-oriented DEA (Emami Meibod, 2000).

After the linear transformation and solving the linear programming model, the coefficients of inputs and outputs are calculated in a way that efficiency ratio of zero decision-making unit is maximized. This method measures the efficacy in an optimistic way. In other words, in this method within a set of comparable decision-making units (DMUs), the units that have the best performance and make up an efficiency frontier, are identified.

On the other hand, the performance of DMUs can be measured from the pessimistic view that contrary to the optimistic model is searching for the most unfavorable set of weights for each DMU, and uses inefficient frontier to determine the worst relative efficiency score that can be assigned to each unit. Units lying on the inefficiency frontier are defined as pessimistically inefficient, and units not lying on the inefficiency frontier are defined as not pessimistically inefficient. Pessimistic efficiency or worst relative efficiency of DMUs could be estimated using relation 2 (Aziz & Wang, 2013).

$$\text{Max } \varphi = \frac{\sum_{i=1}^m v_i x_{ij}}{\sum_{r=1}^s u_r y_{rj}} \qquad (\text{٢})$$

s.t

$$\frac{\sum_{i=1}^m v_i x_{ij}}{\sum_{r=1}^s u_r y_{rj}} \leq 1$$

$u_r, v_i \geq 0$

If there are a set of positive weights that make $\varphi = 1$, then those units will be pessimistically

inefficient. All pessimistically inefficient units determine an inefficiency frontier, and units not lying on inefficiency frontier are not necessarily meant to be on the efficiency frontier, as it is possible to be located between efficient and inefficient frontiers (Aziz, 2012).

The conventional DEA uses accurate and definite data to measure the efficiency, but in the real world there are risks and uncertainties. Therefore, one cannot use precise and definite data, and specify accurate values for each of the outputs and inputs. In order to tackle this problem, you can use Interval DEA.

Wang and Chin (2009) proposed a model of bounded efficiency to assess the overall performance of units in which efficiency is demonstrated as an interval for every unit. Bounded DEA where DEA approach is output oriented, uses an ideal decision making unit (IDMU) which provides maximum output with minimum input, and calculates their efficiency from a pessimistic view based on relation 3,

$$\text{Max } \varphi_{IDMU} = \sum_{r=1}^s v_i x_i^{min} \qquad (3)$$

s.t:

$$\sum u_r y_{rj} - \sum v_r x_{rj} \geq 0$$

$$\sum u_r y_r^{max} = 1$$

$$u_r \geq \varepsilon, v_i \geq \varepsilon$$

where x_i^{min} represent the minimum x_i and y_i^{max} maximum y_i.

There is no doubt this IDMU is the best unit among units of the study, and its pessimistic efficiency should be better than all units. Thus, after determining the ideal unit efficiency, one can measure the efficiency of the units in $[\varphi_{IDMU}, 1]$ which is shown in relation 4.

$$Max/Min\mu = \frac{\sum_{i=1}^m v_i x_{io}}{\sum_{r=1}^s u_r y_{ro}} \qquad (4)$$

s.t:

$$\varphi_{IDMU} \leq \frac{\sum_{i=1}^m v_i x_{ij}}{\sum_{r=1}^s u_r y_{rj}} \leq 1$$

$$u_r, v_i \geq \varepsilon$$

Once, there is zero for each input, then $x_i^{min} = 0$ and as $0 = \varphi_{IDMU}$ the above planning model will not be able to calculate range efficiency for each set. To solve this problem, Azizi and Jahed (2011) suggested that optimistic efficiency use α coefficient to be modified so that:

$$(5)$$

$\alpha \leq min \{ \varphi_j / \theta_j \}$ or $\alpha \; \theta_j \leq \varphi_j$

where optimistic and pessimistic efficiency form a range which is shown with $[\mu^L, \mu^U]$. According to their proposal, α is calculated based on the following relation. μ according to following planning model, can measure the overall efficiency of the units in $[\alpha, 1]$ (Aziz & Fathi, 2010).

$$\text{Max/min } \mu = \frac{\sum_{i=1}^{m} v_i x_{io}}{\sum_{r=1}^{s} u_r y_{ro}} \qquad (6)$$

s.t:

$$\alpha \leq \frac{\sum_{i=1}^{m} v_i x_{ij}}{\sum_{r=1}^{s} u_r y_{rj}}$$

$$u_r, v_i \geq 0$$

Relation 6 could be transformed into two linear programs as follows:

$$\text{Max/ min } \mu = \sum_{i=1}^{m} v_i x_{io} \qquad (7)$$

s.t:

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \geq 0$$

$$\sum_{r=1}^{s} u_r (\alpha y_{rj}) - \sum_{i=1}^{m} v_i x_{ij} \geq 0$$

$$\sum u_r y_{ro} = 1$$

$$u_r \geq 0, v_i \geq 0$$

If the maximum and minimum in relation 7 are shown with μ^U and μ^L, then overall efficiency of the units is calculated in the range of $[\mu^L, \mu^U]$ (Aziz & Jahed, 2012). If μ^U is equal to 1, that unit is pessimistically inefficient. If a unit is both optimistically efficient and pessimistically inefficient, that unit is a special one, then, we can say the unit is neither the best nor the worst. If a unit is neither optimistically efficient, nor pessimistically inefficient, it is called an indefinite unit, these units are enclosed between efficient and inefficient frontiers (Aziz, 2012).

3. Theoretical Foundations

Data Envelement Analysis (DEA) is a data approach to evaluate the performance of a set of congruent entities called decision-making units (DMU) whose performance is calculated based on multiple measurement. Conventional DEA which is based on the concept of the efficiency frontier, determines the best efficiency score which could be assigned to each DMU. Based on these scores, DMUs are divided into optimistically efficient DEA or optimistically inefficient DEA, and

efficient DMUs of DEA delineate an inefficiency frontier. There is a similar approach which uses the concept of inefficiency frontier to determine the worst relative efficiency score that could be applied to any DMU. DMUs lying on the inefficiency frontier are defined as the inefficient DEA or pessimistic inefficiency, and those that are not lying on the inefficiency frontier are called none-inefficient DEA or pessimistically inefficient (Azizi & Wang, 2013). In this paper, both relative efficiencies for health houses are considered. To measure the overall performance of DMUs, it is suggested that both efficiencies are integrated in the form of a range, which in this case the proposed DEA models for measuring efficiency are called bounded DEA. Thus, the efficiency range of all possible values of efficiency that reflect different perspectives will be at decision-makers' disposal. In this paper, to measure the performance of health houses (DMUs), both efficiencies at the same time and in the form of efficiency range have been merged.

Health houses are the first rural healthcare centers in a health system aimed to provide health services and play an important role in preventing diseases and preserving the public health, as improving health indicators in rural areas has been made possible thanks to such efforts.

Depending on the geographical situation, especially the communication facilities and the population, each health house covers one or several villages, and the key role of these houses is when in the most remote villages of the country, they provide necessary healthcare services for the villagers and they prevent the spread of diseases in the community (Mahmudifar, 2007).

4. Findings

Results related to output and input oriented efficiency of health houses indicate that among the units surveyed, nine units of Garask, Koru Roud Khaneh, Malat, the lower Leyla Kouh, Kafsh Kan Mahaleh, Moridan, Ganjali Sara, and Hajji Sara were on the efficiency frontier, and other units were inefficient. The average optimistic efficiency at output-oriented and input-oriented version is 1.645. In other words, to obtain a single product unit, the weighted sum of inputs consumed would be equal to 1.645. It is clear the smaller this value, the better the efficiency of the unit meaning that the unit needs less input to get

the same amount of output. In input-oriented version, the average efficiency was 0.688. This amount suggests that it is possible to get 0.688 product through consumption of one input. The higher value suggests that more product is produced from a certain amount of input and it represents higher productivity (table 1).

Table 1. Efficiency of Health Houses in both Output and Input Oriented Versions
(Source: Research findings, 2016)

Rows	Output oriented	Input oriented	Rows	Output oriented	Input oriented
1	1.844	0.531	24	1.622	0.617
2	1.658	0.603	25	1.474	0.678
3	1	1	26	1.910	0.524
4	1.125	0.889	27	1.582	0.632
5	1	1	28	1	1
6	2.300	0.435	29	1	1
7	1.237	0.808	30	1.519	0.658
8	1.249	0.801	31	1.278	0.782
9	2.098	0.477	32	1.631	0.613
10	1.875	0.533	33	2.160	0.463
11	2.172	0.460	34	1.622	0.617
12	2.508	399	35	1.857	0.539
13	2.734	0.366	36	2.021	0.495
14	1	1	37	1.323	0.756
15	1.139	0.878	38	1.842	0.543
16	1.116	0.896	39	2.524	0.396
17	1.007	0.993	40	3.871	0.258
18	1	1	41	2.399	0.417
19	1	1	42	1.996	0.501
20	1.702	0.588	43	1.225	0.816
21	1.229	0.814	44	1	1
22	1.211	0.826	45	1	1
23	2.297	0.342	Average	1.645	0.688

For example, health houses in Lower Salkoyeh, Talesh Mahaleh, Tazeh Abad are between efficiency and inefficiency frontiers. Although, these units do not operate optimistically efficient, they are not pessimistically on inefficiency frontier. To obtain an output unit, the maximum quantities of inputs are consumed.

For example, the weighted sum of inputs for unit number one, which is inefficient from a pessimistic view, is equal to one, but this value for unit number two which is on the inefficiency frontier is 0.721 (Table 2).

Table 2. Efficiency of Health Houses in both Optimistic and Pessimistic Views
(Source: Research findings, 2016)

Health Houses	Optimistic Efficiency	Pessimistic Efficiency	Health Houses	Optimistic Efficiency	Pessimistic Efficiency
Daryasar	1.884	1	Pileh Mahaleh layl	0.622	0.588
Lower Salkoyeh	1.658	0.721	Lower Parvaresh	1.474	0.422
Dive-Shell	1	0.79	Tazeh Abad Kurd-Sara Kouh	1.910	0.707
Talesh Mahaleh	1.125	0.781	Khorma	1.582	0.513
Lower Leila Kouh	1	0.613	Kordour Khaneh	1	0.599
Lower Nalekiya Shahr	2.300	1	Kafsh Kan Mahaleh	1	0.295
Sadaat Mahaleh	1.249	0.585	Sadaat Mahaleh Koshalshad	1.278	1
Khalikyasar	2.098	0.857	Lowkalayeh	1.631	0.593
Lower Popkiyadeh	1.875	0.584	Miyan Mahaleh Koshal-shad	2.160	1

Upper Popkiyadeh	2.172	0.9	Fatideh	1.622	0.581

Health Houses	Optimistic Efficiency	Pessimistic Efficiency	Health Houses	Optimistic Efficiency	Pessimistic Efficiency
Agha Ali Sara	2.508	0.938	Gol Sephid	1.857	0.762
Pour-Shokuh	2.734	0.945	Darya Kenar	2.021	0.654
Haji Sara	1	0.362	Pir Poshteh	1.323	0.604
Taleb Sara	1.139	0.506	Lot-leil	1.842	0.579
Golab Mahaleh	1.116	0.442	Bolordakan	2.524	1
Liseh Roud	1.007	0.365	Sarleil	3.871	1
Moridan	1	0.312	Lower Siyah Manaseh	2.399	0.824
Malat	1	0.369	Kohlestan	1.996	0.702
Yaghobiyeh	1.702	0.646	Kiya Gahan	1.225	0.813
Sigaroud	1.229	0.554	Garask	1	0.361
Bipass Bagh	1.211	0.543	Ganjali Sara	1	0.4
Lower Shekar-kesh	2.927	1	**Average**	1.645	0.671

In order to obtain the efficiency range of each unit through bounded DEA, one should at first calculate the value of α according to relation 5 and minimum pessimistic efficiency and maximum optimistic efficiency shown in Table 2.

$$\alpha = \frac{min\varphi i}{max\theta i} = \frac{0.295}{3.871} = 0.076$$

After calculating α and adjusting the optimistic efficiency, the efficiency range can be calculated. Results related to the efficiency range of units are summarized in Table 3.

Table 3. Efficiency Range of Health Houses
(Source: Research findings, 2016)

Health Houses	Efficiency range	Health Houses	Efficiency range
Daryasar	(0.144, 1)	Pileh Mahaleh layl	(0.124, 0.585)
Lower Salkoyeh	(0.126, 0.721)	Lower Parvaresh	(0.112, 0.422)
Dive-Shell	(0.76, 0.79)	Tazeh Abad Kurd-Sara kouh	(0.146, 0.707)
Talesh Mahaleh	(0.086, 0.781)	Khorma	(0.121, 0.513)
Lower Leila Kouh	(0.076, 0.613)	Kordour Khaneh	(0.076, 0.599)
Lower Nalekiya Shahr	(0.175, 1)	Kafsh Kan Mahaleh	(0.076, 0.295)
Tazeh Abad	(0.094, 0.472)	Sadaat Mahaleh Nalikiyashahr	(0.116, 0.904)
Sadaat Mahaleh	(0.095, 0.585)	Sadaat Mahaleh Koshalshad	(0.097, 1)
Khalikyasar	(0.143, 0.584)	Miyan Mahaleh Koshal-shad	(0.165, 1)
Lower Popkiyadeh	(0.166, 0.9)	Fatideh	(0.124, 0.581)
Upper Popkiyadeh	(0.160, 0.857)	Lowkalayeh	(0.124, 0.593)
Agha Ali Sara	(0.191, 0.938)	Gol Sephid	(0.142, 0.762)
Pour-Shokuh	(0.208, 0.945)	Darya Kenar	(0.154, 0.654)
Haji Sara	(0.076, 0.362)	Pir Poshteh	(0.101, 0.604)
Taleb Sara	(0.087, 0.506)	Lot-leil	(0.140, 0.579)
Golab Mahaleh	(0.085, 0.442)	Bolordakan	(0.192, 1)
Liseh Roud	(0.077, 0.365)	Sarleil	(0.295, 1)
Moridan	(0.076, 0.312)	Lower Siyah Manaseh	(0.183, 0.824)
Malat	(0.076, 0.369)	Kohlestan	(0.152, 0.702)
Yaghobiyeh	(0.130, 0.646)	Kiya Gahan	(0.093, 0.813)
Sigaroud	(0.094, 0.554)	Garask	(0.076, 0.361)
Bipass Bagh	(0.092, 0.543)	Ganjali Sara	(0.076, 0.4)
Lower Shekar-kesh	(1, 0.223)		

According to Table 3, there is no special unit having both optimistic efficiency and pessimistic inefficiency. Typically, optimistic efficient units have a good performance and inefficient units do not have favorable performance, but this does not mean that every efficient unit has the best performance, and every inefficient unit has the worst performance, rather it is possible that among

the units on the efficiency frontier, a unit compared to other units may have a better ranking in terms of efficiency. Therefore, we may conclude that special units which are both optimistically efficient and pessimistically inefficient are neither the best nor the worst units. On the other hand, 29 units are also uncertain, as they are between efficient and inefficient frontiers, they are neither optimistic efficient nor pessimistic inefficient.

5. Discussion and Conclusion

In this paper, bounded DEA models were used to evaluate the performance of rural health centers (Health Houses) in Langerud County. Bounded DEA models show the efficiency frontiers from optimistic and pessimistic views. It was also shown that optimistic efficient units, pessimistic inefficient and frontiers of efficiency and inefficiency can be identified accurately by using bounded models.

According to the results, out of 45 active health houses in Langerud County, nine are efficient and the remaining units are inefficient. These findings are in line with Shojja, Abri, and Khalili, (2014), evaluating the efficiency of health houses in Firoozkooh County in 2014.

Although 64% of health houses are not efficient, they are not on the inefficiency frontier, which indicates the potential power of units in producing greater output without increasing the amount of input, and consequently creating favorable economic outcomes. Given the adjustment made to optimistic efficiency if the lower limit of efficiency is 0.076, that unit will be efficient.

Average efficiency range of health houses was between 0.123 and 0.671 which shows 64% waste in input consumption. In some units, specific administrative management policies such as reducing the costs and downsizing the work force could be useful. In a unit that has few clients; one clerk could well meet the clients' needs, and properly provided the specified services and made use of the surplus work force in units which did not have enough staff. By this way you can avoid extra costs, and reduce the input costs. DEA approach with the frontiers of efficiency and inefficiency has significant advantage over current methods for evaluating the DMU. This method can easily and correctly identify the best DMU.

In this study, which was carried out in Langerud County, the average efficiency of 36 inefficient health houses was 61 percent; this indicates that 39 percent of potential average reduction of inputs has

no effect on outputs. This finding is in harmony with the assertions Haji Ali Afzali (2007) and Muhammadi (2015) made, which were mentioned in the review of literature section.

DEA approach employed in this study showed that 80 percent of rural health houses are inefficient and 20 percent are efficient which indicates that a high percentage of the units are inefficient. This amount could be compared with the results of Marshall and Flessa (2008) with 30% of inefficient units in rural health centers in Burkina Faso.

The percentage of efficient units in this study, in which 45 rural health house were evaluated by the DEA, is in harmony with Caballer and Tarazon's (2010) findings in the study that was conducted on 22 hospitals in Valencia, which had 6 efficient and 16 inefficient units.

Identification of efficient and inefficient units could be the first step in planning and policy-making to increase the efficiency and education planning for rural health houses. Besides, using efficient healthcare units as paragons, and assessing educational requirements of inefficient healthcare centers would provide useful information for planners and policy makers.

The concept and results of efficiency and inefficiency in this study are relative, and only show the status of rural healthcare centers in comparison with other healthcare centers. To rigorously examine the efficiency of health houses and achieve accurate results and provide a complete picture of the efficiency of health houses, we need to check the efficiency of other health houses or even healthcare centers. Creating a motivational and incentive system that rewards employees and managers of efficient units or units that have positive growth could further enhance their productivity and efficiency, and encourage other inefficient units to work more. Inefficient health houses can use efficient health houses as a paragon and become efficient by reducing the costs or increasing the output, for example, through increasing the number of outpatients, etc. Operational strategies such as upgrading the professional and practical knowledge of the staff, repairing, rebuilding, and maintaining equipment and physical space, and developing an operational plan for the appropriate distribution of manpower and equipment in rural healthcare centers can play a significant role in improving the technical performance of these units.

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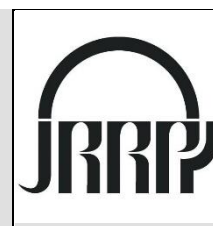
کاربرد تحلیل پوششی داده‌ها با استفاده از مرزهای کارا و ناکارا در بررسی کارایی خانه‌های بهداشت روستایی (مطالعه موردی: شهرستان لنگرود)

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چکیده مبسوط

۱. مقدمه

دسترسی به تسهیلات و خدمات سلامت یکی از مؤثرترین عوامل حفظ و ارتقاء سلامت جامعه بشـمار مـی‌رود. خانـه‌هـای بهداشـت بـه‌عنـوان واحدهای بهداشتی مستقر در روستاها نماد توسعه سلامت هسـتند کـه اثرات ارزشمندی را در ارتقاء سطح سلامت و بهبود شاخص سـلامتی منطقه خود دارند. ایجاد بهبود در هـر سـازمانی نیازمنـد انـدازه‌گیـری عملکرد سازمان، برنامه‌ریزی و هدف‌گذاری جهت بهبود عملکرد مـی‌-باشد. مهمترین معیار قضاوت در خصوص عملکرد کلیـه سـازمان‌هـا، کـارایی آن‌ها می‌باشد. این مطالعه با هـدف بررسـی کـارایی خانـه‌هـای بهداشت روستایی شهرستان لنگرود صورت گرفته است.

۲. مبانی نظری

تحلیـل پوششـی داده‌هـا (DEA) یـک رویکـرد داده‌ای بـرای ارزیـابی عملکرد مجموعه‌ای از موجودیت‌های متجانس به‌نام واحدهای تصمیم‌-گیری (DMUها) است که عملکرد آن‌ها براسـاس انـدازه‌هـای متعـدد مشخص می‌شود. DEA سنتی که مبتنی بر مفهوم مرز کـارایی اسـت، بهترین نمره کارایی را تعیین مـی‌کنـد کـه مـی‌تـوان بـه هـر یـک از DMUها اختصاص داد. DMUها براساس این نمرات به‌عنـوان کـارای DEA (کارای خوش‌بینانه) یا غیرکارای DEA (غیرکـارای خوش‌بینانه) تقسیم‌بنـدی مـی‌شـوند و DMUهـای کـارای DEA، مـرز کـارایی را مشخص می‌کنند. رویکرد مشابهی وجود دارد که از مفهوم مرز ناکارایی

برای تعیین بدترین نمره کـارایی نسـبی کـه مـی‌تـوان بـه هـر DMU اختصاص می‌کند، استفاده می‌کند. DMUهای واقع روی مرز ناکـارایی بـه‌-عنوان ناکارای DEA یا ناکارای بدبینانه تعیین می‌شوند و آن‌هـایی کـه روی مرز ناکارا نیسـتند، بـه‌عنـوان غیرناکـارای DEA یـا غیرناکـارای بدبینانه اعلام می‌شوند. در مقاله حاضر این بحث مطرح می‌شود که هر دو کارایی نسبی را برای خانه‌های بهداشت باهم در نظر گرفت. بـرای اندازه‌گیری عملکرد کلی DMUها، پیشنهاد می‌شود که هر دو کـارایی در قالب یک بازه ادغـام شـود کـه در ایـن صـورت مـدل‌هـای DEA پیشنهادی برای اندازه‌گیری کارایی را مدل‌های DEA کراندار می‌نامیم. به این ترتیب بازه کارایی تمام مقادیر ممکن کـارایی را کـه مـنعکس‌-کننده دیدگاه‌های مختلف هستند، در اختیار تصمیم‌گیرنده قـرار مـی‌-دهد. در این مقاله برای کارایی خانه‌های بهداشت (واحدهای تصمیم‌-گیری)، هر دو کارایی همزمان و در قالب بازه کارایی باهم ادغام شده‌اند. خانه‌های بهداشت، نخستین و محیطی‌ترین واحد روسـتایی ارائه خدمت در نظام شبکه‌های بهداشتی درمانی کشور به شـمار مـی‌رونـد و نقـش مهمی در پیشگیری از بیماری‌ها و صیانت از سلامت مردم را بـه عهـده دارند، به‌طوری‌که ارتقـای شـاخص‌هـای بهداشـتی کشـور بـه ویـژه در روستاها مرهون فعالیت‌های آن‌هاست. هـر خانـه بهداشـت بسـته بـه شرایط جغرافیایی، به‌ویژه امکانات ارتباطی و جمعیـت، یـک یـا چنـد روستا را تحت پوشش خود دارد و نقش کلیـدی ایـن خانـه‌هـا، زمـانی مشخص می‌شود که در دور افتاده‌ترین روستاهای کشور با ارائه خدمات

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بهداشـتی لازم بـه روسـتاییان، از بـروز بیمـاری در جامعـه پیشـگیری می‌کنند.

۳. روش تحقیق

پژوهش حاضر، توصیفی – تحلیلی و داده‌های آن از نوع مقطعی اسـت کـه در سال ۱۳۹۵ به‌صـورت میـدانی در ۴۵ خانـه بهداشـت روسـتایی شهرستان لنگرود جمع‌آوری شد. اطلاعات مورد نیاز با اسـتفاده از آمار و مستندات موجود، جمع‌آوری و با نـرم‌افزارهـای Windeap و GAMS بررسی شد. در این پژوهش برای ارزیابی عملکرد خانـه‌هـای بهداشـت اقدام به تعیین۲ ورودی شـامل: هزینـه مصـرفی و تعـداد بهـورز و ۳ خروجی شامل: مـراجعین بهداشـت خـانواده، مـراجعین بیمـاری هـا و مراجعین پانسمان در بازه زمـانی فـروردین ۱۳۹۴ تـا فـروردین ۱۳۹۵ شد.

۴. یافته های تحقیق

نتایج نشان داد که ۹ خانه بهداشت روستایی از ۴۵ خانـه بهداشـت بـا کسب نمره کارایی یک، دارای عملکرد کارا می‌باشند. خانه‌های بهداشت گرسک، کورورودخانه و ملاط به ترتیب سه نمره اول کارایی را به خـود اختصاص داده‌اند. نتایج مطالعه نشان مـی‌دهـد کـه میـانگین کـارایی خوش‌بینانه در دو حالت ستاده محـور و نهـاده محـور بـه‌ترتیـب برابـر ۱/۶۴۵ و ۰/۶۸۸ اسـت و ۱۵/۵ درصـد خانـه‌هـای بهداشـت در حالـت بدبینانه ناکارا هستند. همچنین، ۶۴ درصد واحدها بین دو مـرز کـارا و ناکارا احاطه شده و از منظر بدبینانه ناکارا نیستند، در حالی که از منظر خوش‌بینانه نیز روی مرز کارایی قرار ندارند که نشان‌دهنـده زیـاده‌روی در مصرف نهاده‌ها و توان بـالقوه در افـزایش ارائـه خـدمات یـا کـاهش مصرف نهاده‌ها می‌باشد. ۲۹ واحد نیـز واحـدهای نـامعین هسـتند بـه صورتی که بین دو مرز کارا و ناکارا احاطه شده‌اند و نه کارای خوشبینانه و نه ناکارای بدبینانه می‌باشند. با توجه به یافتـه‌هـای تحقیـق، بیشـینه کارایی خوش بینانه ۳/۸۷ و کمینه آن یک، بیشینه کارایی بدبینانه یک و کمینه آن ۰/۲۹ می‌باشد. با توجه به نتایج این مطالعه، پیشنهاد مـی‌-شود با الگو قرار دادن خانه‌های بهداشت کارآمد و نیازسـنجی آموزشـی خانه‌های بهداشت ناکارا نسبت به برنامه‌ریزی در راستای افزایش کارایی اقدام شود.

۵. نتیجه گیری

در این مقاله مدل‌های DEA کراندار برای ارزیابی عملکرد خانـه‌هـای بهداشت لنگرود مورد استفاده قرار گرفت. مـدل‌هـای DEA کـران‌دار، کران‌های کارایی را از دیـدگاه خوش‌بینانه و بدبینانـه نشان مـی‌دهـد. همچنین نشـان داده شـد کـه واحـدهای کـارای خوشبینانه، ناکارای بدبینانه و نیز مرزهای کارایی و ناکارایی را می‌توان به دقت با استفاده از مدل‌های کراندار شناسـایی نمـود. میـانگین کـارایی بـازه‌ای خانـه‌ای بهداشت در محدوده ۰/۱۲۳ و ۰/۶۷۱ قرار داشت که بیـانگر زیـاده‌روی در مصرف نهاده به میزان ۶۴ درصد مـی‌باشد. ۶۴ درصد خانـه‌هـای بهداشت هر چند به‌صورت کارا عمل نمی‌کنند ولی روی مـرز ناکـارایی نیز قرار ندارند، که گویای توان بالقوه واحدها در تولید بیشـتر سـتاده‌هـا بدون افزایش مقدار نهاده‌ها باشد و این امـر مـی‌توانـد نتـایج اقتصـادی مطلوبی را به دنبال داشته باشد. با توجه به تعدیل کارایی خـوش‌بینانـه در صورتی که حد پایین کـارایی معـادل ۰/۰۷۶ قـرار داشـته باشـد آن واحد کارا خواهد بود. واحد ویژه که هم کـارای خوشبینانه و هم ناکارای بدبینانه می‌باشد، وجود ندارد..

با توجه به یافته‌های تحقیق ماکزیمم کـارایی خوشـبینانه در برخی از واحدها باسیاست‌های خاص مدیریتی چون کم کردن هزینه مصـرفی و راهکار تعدیل نیرو می‌تواند کارساز باشـد، واحـدی کـه بـار مراجعاتش بسیار پایین باشد یک نیرو هم می‌تواند به‌خوبی پاسـخ‌گـوی مـراجعین بوده و خدمات تعریف شده را به‌خوبی انجام دهد و از نیروی مازاد برای واحدی که دارای نیروی کافی نمی‌باشد استفاده کرد و از اتلاف هزینه-ها جلوگیری و در مصرف نهاده صرفه‌جویی نمود.

کلمات کلیدی: کارایی خوش‌بینانه؛ کارایی بدبینانه؛ کارایی بازه‌ای؛ سلامت.

ارجاع: هادی‌پور، ح.، کاوسی کلاشمی، م.، سالاری، ا. و معتمد، م. ک. (۱۳۹۶). کاربرد تحلیل پوششی داده‌ها با استفاده از مرزهای کارا و ناکارا در بررسی کارایی خانه‌های بهداشت روستایی (مطالعه موردی: شهرستان لنگرود). *مجله پژوهش وبرنامه‌ریزی روستایی، ۶*(۳)، ۲۱۶-۲۰۳.
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