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# Application of Two-Stage DEA Technique for Efficiencies Measuring of Private Insurance Companies in Iran

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**Abstract** Traditional DEA models ignore the internal process of production systems and are not able to identify the cause of deficiency in efficiencies measuring. At this research, traditional DEA model and two-stage DEA model were used to measure the efficiency of Iranian private insurance companies during 2007-2009. The results indicated that the traditional DEA model is not suitable for such kind of network systems. In marketing perspective, Melat and Hafez companies were efficient during the study period. But these two companies are not efficient due to weakness in investment sub-process. Wilcoxon's signed-rank test was used to identify the main reason of weakness between efficiency average of marketing sub-process and investment sub-process with significant level of 0.01. The results indicated that the investment weakness is the main reason of insurance companies' deficiencies during the studied period.

**Keywords** Two-Stage DEA, Insurance Industry, Marketing Sub-Process, Investment Sub-Process.

## 1 Introduction

Insurance industry extends the productivities and services with providing safety and confidence. Insurance industry also causes stability and reduces the anxiety due to identification. These companies accomplish the governmental social program as well as allocating the sources in a rational manner. Furthermore, these companies have positive effects on economics growth of the country. Therefore, the efficiency of the insurance companies is always under the question mark. Efficiency measurement in the insurance companies increases the quality of their activities and also assists them to identify and solve the problems [1]. Measuring the performance of a production system is an important task for the purpose of control and planning. Data envelopment analysis (DEA) is a technique that is widely applied to measure the relative efficiency of a set of production systems, or decision making units (DMUs) which apply the same inputs to produce the same outputs. This method identifies all of the DMUs with weak performance and also shows the sources of inefficiency [2]. Traditional studies in DEA view systems as a whole, ignoring the performance of their component processes to calculate the relative efficiency of a set of the production systems.

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The first deficiencies are that the efficiency score may not properly represent the aggregate performance of the processes of a system. The second deficiencies are that the traditional DEA does not show which process causes the low efficiency of an inefficient system. In order to identify the source of inefficiency, it is possible to calculate the efficiency of each process independently. However, the relationship between the efficiency of the system and those of the processes is not revealed [3]. There are several studies showing the deficiency of traditional DEA model such as [3-7]. Traditional DEA is considers the DMUs activities as a black box and ignore the intermediate measures [5]. The traditional DEA may give high score to the overall efficiency but in fact that the sub-processes are not efficient [3].

There are many studies dealing with network systems which include internal processes. Seiford and Zhu [8] divide a commercial bank production process into the stages of profitability and marketability. The inputs of the bank production process are employees, assets and shareholders equity, which are also the inputs of the first stage. The output of the bank production process is market value, total return on investments, and earning per share which are also the output of the second stage. There are two intermediate products, revenues and profits, which are the outputs of the first stage as well as the inputs of the second stage. Kao and Hwang [9] measured the efficiency of non-life insurance companies with two-stage DEA model in Taiwan. They divided the production process of non-life insurance companies to two sub-processes premium acquisition and profit generation. A two-stage DEA model partially improves these deficiencies. Recently, DEA has been extended to examine the efficiency of the two-stage processes, where all the outputs from the first stage are intermediate measure that makes up inputs to the second stage [10]. Insurance industry provides services to their clients to generate profit. There are several studies which used the DEA technique to measure the managerial performance of this industry [11].

The profit is not earned from insurance service alone. An insurance company uses the insurance premium acquired through the systems of agencies, broker, solicitors, etc [9]. Zha and Liang [12] considered production to describe the cooperation between different stages efficiency and banks, overall assessment.

Production process in the insurance industry is consisted with two sub-processes called marketing and investment. The output of the marketing sub-process is the input of the investment sub-process.

The aim of this research is to measure the efficiency of private insurance companies via two-stage DEA model in Iran during 3 years. There are several studies dealing with the efficiency measurement of insurance companies in Iran, but they have used traditional DEA method that ignores the internal process of production systems. Therefore, this research is different from the previous studies treating the whole production process and the two sub-processes as independent. Moreover, this paper takes the series relationship of the two sub-processes into account in measuring the efficiencies of the Iranian private insurance companies.

## 2 Material and methods

Data was collected from 14 private insurance companies in Iran from 2007 to 2009. Input and output was earned from financial sheet of the companies [13]. Marketing and investment sub-processes were considered (Figure 1). Marketing sub-process inputs includes the operation expenditures ($x_1$), insurance expenditures ($x_2$). Marketing sub-process outputs includes direct

written premiums ($z_1$) and reinsurance premiums ($z_2$) with inputs of the investments sub-process.

Output of investments sub-process consists of underwriting profit ($Y_1$) and investment profit ($Y_2$). The operation costs and insurance costs in sub-process of marketing are covered by clients and the other insurance companies. Clients pay direct written premiums and reinsurance premiums paid by the other insurance companies. The sub-process of investment premiums are invested in a portfolio to earn profit.

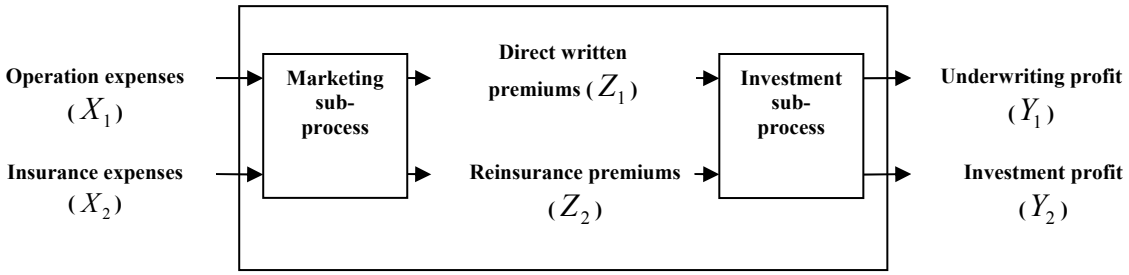


**Fig. 1** Production system of the private insurance companies in Iran

Inputs of the system, which are also the input of the first stage (marketing), are as follows:
Operation expenses ($x_1$): Salaries of the employees and various types of costs incurred in daily operation such as personnel costs, administrative and public costs)
Insurance expenses ($x_2$): expenses paid to agencies, brokers and solicitors, and expenses associated with marketing the service of insurance such as reinsurance premium, wage of damages and etc.)

Intermediate products in the system, which are the outputs of the marketing sub-process as well as the inputs of the investment sub-process, are as follows:

Direct written premiums ($z_1$): Premiums received from insured clients.
Reinsurance premiums ($z_2$): Premiums received from ceding companies.

Outputs of the system, which are also the outputs of investment stage, are as follows:
Underwriting profit ($Y_1$): Profit earned from the insurance business.
Investment profit ($Y_2$): Profit earned from the investment portfolio includes banking deposit revenue, coupon-bond revenue, loan revenue, etc.

Insurance production of Iranian industry is based on two-stage network structure (Fig 1). Therefore the traditional DEA model is not a rational manner to measure the efficiencies of this industry.

Kao and Hwang [9] used a two-stage DEA model to measure the efficiencies on non-life insurance companies in Taiwan. Therefore, at this research their model was used to measure the efficiencies of Iranian private insurance companies.

First of all, the overall efficiency was measured. Then, the first stage efficiency was measured considered to the overall efficiency. The second stage efficiency was determined whereas the overall efficiency was divided to the first stage efficiency. Wilcoxon's signed-rank test was used to confirm that the efficiency of the first stage is higher that the second stage in a statistical sense. This shows that the low efficiency score of the whole production process is mainly due to the low efficiency score of the second stage. As mentioned before the private insurance companies in Iran have a network system with series structure; hence, these kinds of systems will be discussed.

## 3 Network systems

Systems with more than one process connected with each other are called networks [3]. Outputs of the first stage are as the inputs of the second stage that they called as intermediate data [12]. There are two basic structures for the network systems, series and parallel, in the both systems efficiency and deficiency can be divided into efficiency and deficiency of the internal process.

In a series structure the whole internal processes are connected in a series form where as the outputs of the each process are as the inputs of the next process that they called as the intermediate data. The intermediate data of the last process are the outputs of the system. The number of intermediate products can be different for each process. At this status, a DMU is efficient only if all its processes are efficient. The system efficiency will be low if there is a process which is very inefficient and will be high only when all processes have high efficiencies. In a parallel structure the whole internal processes are connected in a parallel form. At this status the sum of input for all processes is equal to the input of the system of this is the same for the output. If a process is efficient in the parallel system, it will be preferable to use this process alone for production. Since the underlying assumption of the CCR model is constant returns to scale, the system will be efficient if this efficient process consumes all of the inputs for production [3]. To measure the efficiency of a network system a network DEA model is needed. Different from the traditional DEA model, the network DEA model does not have a standard form. It depends on the structure of the network in question.

There are four procedures for a two-stage system: Standard DEA approach; efficiency decomposition approach; network-DEA approach and game-theoretic approach. Except for the standard DEA approach, all other approaches attempt to correct for the above-referenced conflict issue [14].

At this research the procedure of efficiency decomposition and two-stage DEA model were used and these methods will be discussed.

DEA models treat the DMU as a "black box" Inputs enter and outputs exit, with no consideration of the intervening stages. Consequently, it is difficult, if not impossible, to provide individual DMU managers with specific information regarding the sources of inefficiency within their DMUs [7, 15].

## 4 Two-stage DEA model

Denote $X_{ik}$, i=1,…,m and $Y_{rk}$, r=1,…,s as *i*th input and *r*th output, the traditional DEA model to measure the efficiency of DMU *k* under the assumption of constant returns-to-scale is the CCR model:

$$E_k = \text{Max} \sum_{r=1}^{s} u_r Y_{rk}$$

s.t.

$$\begin{aligned} &\sum_{i=1}^{m} v_i X_{ik} = 1, \\ &\sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \le 0, \qquad j = 1,...,n, \\ &v_i, u_r \ge \varepsilon, \qquad i = 1,...m, \qquad r = 1,...,s. \end{aligned} \tag{1}$$

$E_k$ is the relative efficiency of DMU *k*. If $E_k$ =1 shows the DMU *k* is efficient and if $E_k$ <1 indicate the DMU k is inefficient.

Consider a two-stage network structure or processes as shown in Fig. 1, for each of a set of *n* DMUs, we assume each DMUj (*j*=1,2,…, *n*) has *m* inputs $X_{ik}$, (*i*=1,2,…, *m*) to the first stage, and q outputs $Z_{pk}$, (*p*=1,…,*q*) from that stage. These q outputs then become the inputs to the second stage and will be referred to as intermediate measures. The outputs from the second stage are $Y_{rk}$, (*r* =1,2, …, *s*). We denote the efficiency for the first stage as $E_k^1$ and second stage as $E_k^2$, for each DMUj.

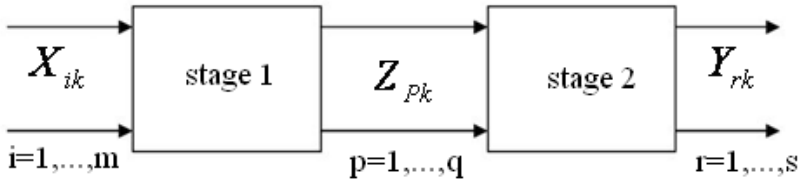


**Fig. 2** Two-stage system of DMU *k*

Seiford and Zhu [8] used the model (1) to measure the overall efficiency and the models 2,3 cited below to measure the efficiencies of first stage ($E_k^1$), and second stage ($E_k^2$).

These models ignore interrelationship between internal processes and calculate the stages efficiencies independently.

$$E_k^1 = \text{Max} \sum_{p=1}^{q} w_p Z_{pk}$$

s.t.

$$\begin{aligned} &\sum_{i=1}^{m} v_i X_{ik} = 1, \\ &\sum_{p=1}^{q} w_p Z_{pk} - \sum_{i=1}^{m} v_i X_{ik} \le 0, \quad j = 1,...,n, \\ &v_i, w_p \ge \varepsilon, \ i = 1,...,m, p = 1,...,q. \end{aligned} \tag{2}$$

$v_i$ is a weight given to input $i$, $w_p$ is a weight given to intermediate $p$, $X_{ik}$ is the data value $i$ from DMU $k$ and $Z_{pk}$ is the intermediate data value $p$ from DMU $k$.

$$E_k^2 = \max \sum_{r=1}^{s} u_r Y_{rk}$$

s.t.

$$\begin{aligned} &\sum_{p=1}^{q} w_p Z_{pk} = 1, \\ &\sum_{r=1}^{s} u_r Y_{rk} - \sum_{p=1}^{q} w_p Z_{pk} \le 0, \quad j = 1,...,n, \\ &w_p, u_r \ge \varepsilon, \ p = 1,...,q, r = 1,...,s. \end{aligned} \tag{3}$$

$w_p$ is a weight given to intermediate $p$, $u_r$ is a weight given to output $r$, $Z_{pk}$ is the intermediate data value $p$ from DMU $k$ and $Y_{rk}$ is the data value output $r$ from DMU $k$

Kao and Hwang [9] introduced the models (2,3) which are the same as model (1). Therefore, the efficiencies of the whole process and two sub-processes are calculated independently. To link the two sub-processes with the overall process, a model must describe this series relationship between the overall process and two sub-processes. Model (4) was introduced by them according to this concept:

$$E_K = \text{Max} \sum_{r=1}^{s} u_r Y_{rk}$$

s.t.

$$\begin{aligned}
&\sum_{i=1}^{m} v_i X_{ik} = 1, \\
&\sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \le 0, \qquad j = 1,...,n, \qquad (4)\\
&\sum_{p=1}^{q} w_p Z_{pj} - \sum_{i=1}^{m} v_i X_{ij} \le 0, \qquad j = 1,...,n, \\
&\sum_{r=1}^{s} u_r Y_{rj} - \sum_{p=1}^{q} w_p Z_{pj} \le 0, \qquad j = 1,...,n, \\
&v_i, w_p, u_r \ge \varepsilon, \quad i = 1,...,m, \quad p = 1,...,q, \quad r = 1,...,s.
\end{aligned}$$

$v_i$ is a weight given to input $i$, $w_p$ is a weight given to intermediate $p$, $u_r$ is a weight given to output $r$, $X_{ij}$ is the data value $i$ from DMU $j$ and $Z_{pj}$ is the intermediate data value $p$ from DMU $j$ and $Y_{rj}$ is the data value output $r$ from DMU $j$.

Overall efficiency and internal process efficiency are calculated after solving model 4 and determining the coefficients of $u_r^*, v_i^*, w_p^*$.

$$E_k = \frac{\sum_{r=1}^{s} u_r^* Y_{rk}}{\sum_{i=1}^{m} v_i^* X_{ik}}, \qquad E_K^1 = \frac{\sum_{p=1}^{q} w_p^* Z_{pk}}{\sum_{i=1}^{m} v_i^* X_{ik}}, \qquad E_k^2 = \frac{\sum_{r=1}^{s} u_r^* Y_{rk}}{\sum_{p=1}^{q} w_p^* Z_{pk}}$$

The optimal coefficients solved from model 4 may not be unique; consequently, the decomposition of $E_k = E_k^1 \times E_k^2$ would not be unique. This makes the comparison of either $E_k^1$ or among $E_k^2$ all DMUs lack a common basis. TO solve this problem we may find the set of coefficients which produces the largest $E_k^1$ while maintaining the overall efficiency score at $E_k$ calculated from the Model (4). Therefore, model 5 was presented by Kao and Hwang [10] as follows:

$$
\begin{aligned}
& E_k^1 = \mathrm{Max} \sum_{p=1}^{q} w_p Z_{pk} \\
& \text{s.t.} \\
& \sum_{i=1}^{m} v_i X_{ik} = 1, \\
& \sum_{r=1}^{s} u_r Y_{rk} - E_k \sum_{i=1}^{m} v_i X_{ik} = 0, \\
& \sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \le 0, \qquad j = 1,...,n, \\
& \sum_{p=1}^{q} w_p Z_{pj} - \sum_{i=1}^{m} v_i X_{ij} \le 0, \qquad j = 1,...,n, \\
& \sum_{r=1}^{s} u_r Y_{rj} - \sum_{p=1}^{q} w_p Z_{pj} \le 0, \qquad j = 1,...,n, \\
& u_r, v_i, \ w_p \ge \varepsilon, \quad r = 1,...,s, \ \ i = 1,...,m, \quad p = 1,...,q.
\end{aligned}
\tag{5}
$$

## 5 Wilcoxon's signed-rank test

Wilcoxon signed-rank test was used in this research to confirm the null hypothesis ($H_0$). Null hypothesis is that there is a significant difference between efficiency of the first and second stages, whereas the efficiency of the first stage ($\mu_1$) is higher than the second stage ($\mu_2$). It has been shown below:

$$H_0 : \mu_1 \ge \mu_2$$
$$H_1 : \mu_1 < \mu_2$$

The Wilcoxon signed-rank test is a non-parametric statistical hypothesis test used when comparing two related samples or repeated measurements on a single sample to assess whether their population means differ. Wilcoxon statistics is a sum of rang values for each measure in sample(s). As Student's test, it can be used to search differences between two samples or to compare one sample to zero. The test procedure is such that the data is ranked from the smallest value to the largest value and the sum of the ranks of two samples are calculated, which called $R_1$ and $R_2$. If the number of samples are called $n_1$ and $n_2$ then the statistics of $u_1$ and $u_2$ are calculated as follows [16]:

$$R_1 + R_2 = \frac{(n_1 + n_2)(n_1 + n_2 + 1)}{2},$$

$$u_1 = R_1 - \frac{n_1(n_1+1)}{2}$$
$$u_2 = R_2 - \frac{n_2(n_2+1)}{2}$$

the means and variances of $u_1$ and $u_2$ are:

$$\mathrm{E}(\mathrm{u}_1) = \mathrm{E}(\mathrm{u}_2) = \frac{\mathrm{n}_1\mathrm{n}_2}{2}$$
$$\mathrm{V}(\mathrm{u}_1) = \mathrm{V}(\mathrm{u}_2) = \frac{\mathrm{n}_1\mathrm{n}_2(\mathrm{n}_1+\mathrm{n}_2+1)}{12}$$

Finally, the statistics of test is calculated as follows and it's compared with the critical values ($z_\alpha$) in significant level of 1%.

$$Z = \frac{u - E(u)}{\sqrt{V(u)}}$$

## 6 Case study

The sample sizes at this research were 14 private insurance companies in Iran (Table 1). These companies includ Moalem, Parsian, Tosieh, Razi, Karafarin, Sina, Melat, Iran Moein, Omid, Hafez, Day, Saman, Novin and Pasargad.

Data including operation expenses ($x_1$), insurance expenses ($x_2$), direct written premiums ($z_1$), reinsurance premiums ($z_2$), investment profit ($Y_1$) and underwriting profit ($Y_2$) were collected during 2007-2009 [13].

Two stage DEA techniques via LINGO 8 software were used in order to measure the efficiencies of the insurance companies.

## 7 Results

Data including input, intermediate and output from 14 Iranian private insurance companies have been shown in table 1 in year 2007.

**Table 1** Input ( $X$ ), intermediate ( $Z$ ) and output ( $Y$ ) from 14 Iranian private insurance companies in year 2007 (Iranian Million Rial)

| Insurance companies | Operation expenses ($x_1$) | Insurance expenses ($x_2$) | Direct written premiums ($z_1$) | Reinsurance premiums ($z_2$) | Underwriting profit ($Y_1$) | Investment profit ($Y_2$) |
|---|---|---|---|---|---|---|
| Moalem | 27701 | 160425 | 222960 | 21812 | 17597 | 30454 |
| Parsian | 38722 | 2497089 | 1495828 | 261383 | 214002 | 76691 |
| Tosieh | 13951 | 41737 | 72743 | 2730 | 14241 | 12171 |
| Razi | 18937 | 502403 | 615238 | 61916 | 42329 | 63566 |
| Karafarin | 83925 | 786488 | 882851 | 83166 | 109992 | 30741 |
| Sina | 43816 | 736338 | 791101 | 105366 | 76425 | 22644 |
| Melat | 42847 | 1162621 | 1431603 | 138717 | 74001 | 169628 |
| Iran Moein | 4753 | 41779 | 64847 | 3163 | 19867 | 12931 |
| Omid | 1326 | 10075 | 13102 | 4101 | 1253 | 2744 |
| Hafez | 3939 | 127625 | 128725 | 4176 | 4160 | 2767 |
| Day | 54802 | 400504 | 435453 | 84204 | 81669 | 15891 |
| Saman | 25585 | 179051 | 247064 | 5600 | 63912 | 11792 |
| Novin | 24638 | 67216 | 167745 | 16104 | 31177 | 24638 |
| Pasargad | 10780 | 68014 | 98135 | 739 | 30971 | 49566 |

Overall efficiency and internal process efficiency of insurance companies were calculated using traditional DEA approach and models 1, 2 and 3 that presented in previous section. Although, the overall efficiency of the insurance companies was calculated using two-stage DEA model through model 4. Marketing sub-process efficiency was calculated based on model 5 (Tables 2, 3 and 4). Investment sub-process efficiency also was calculated with the following ratio:

$$E_K^2 = \frac{E_K}{E_K^1}$$

The results of traditional DEA model in the left side of the table 2 shows that the companies such as Iran Moein and Pasargad are efficient ($E_k$=1) in year 2007 (Table 2). Whereas, these two companies are just efficient in one marketing and investment sub-process. Therefore, there is doubt about the validity of traditional DEA model. There is a contradiction between the result of this model and two-stage DEA model. Result of two-stage DEA model shows that the Iran Moein company has the highest overall efficiency with score efficiency of 0.94 ($E_k$ =0.94). This means that this company is efficient in marketing and investment sub-process. In marketing point of view the companies such as Parsian, Melat, Iran Moein, Hafez and Novin are efficient( $E_k^1$ =1), but all of the above mentioned companies are deficient in investment sub-process( $E_k^2 \neq 1$). The main reason of overall deficiency of the above companies is weakness in investment premiums.

Wilcoxon's signed-rank test was used to identify the main reason of weakness between efficiency average of firs stage and second stage in significant level of 0.01. The null hypothesis is confirmed if we compare the statistics value (-0.07) with critical value ( $z_{0.01}$=-2.32). The result indicated that the null hypothesis is confirmed. Therefore, the investment weakness is the main reason of insurance companies' deficiencies in year 2007.

**Table 2** Efficiency of Iranian private companies in year 2007

| Insurance companies | Traditional DEA model | | | Two-stage DEA model | | |
|---|---|---|---|---|---|---|
| | $E_k$ (model 1) | $E_k^1$ (model 2) | $E_k^2$ (model 3) | $E_k$ (model 4) | $E_k^1$ (model 5) | $E_K^2 = \frac{E_K}{E_K^1}$ |
| Moalem | 0.21 | 0.74 | 0.25 | 0.14 | 0.59 | 0.23 |
| Parsian | 0.65 | 1 | 0.22 | 0.22 | 1 | 0.22 |
| Tosieh | 0.75 | 0.72 | 0.66 | 0.02 | 0.72 | 0.02 |
| Razi | 0.71 | 0.99 | 0.20 | 0.20 | 0.99 | 0.20 |
| Karafarin | 0.28 | 0.71 | 0.36 | 0.22 | 0.61 | 0.36 |
| Sina | 0.37 | 1 | 0.28 | 0.21 | 0.75 | 0.28 |
| Melat | 0.81 | 1 | 0.21 | 0.21 | 1 | 0.21 |
| Iran Moein | 1 | 1 | 0.94 | 0.94 | 1 | 0.94 |
| Omid | 0.18 | 1 | 0.27 | 0.12 | 0.52 | 0.23 |
| Hafez | 0.22 | 1 | 0.83 | 0.08 | 1 | 0.08 |
| Day | 0.32 | 1 | 0.54 | 0.27 | 0.56 | 0.48 |
| Saman | 0.54 | 0.62 | 0.77 | 0.48 | 0.62 | 0.77 |
| Novin | 0.82 | 1 | 0.54 | 0.54 | 1 | 0.54 |
| Pasargad | 1 | 0.72 | 1 | 0.72 | 0.72 | 1 |
| Average | 0.56 | 0.89 | 0.50 | 0.31 | 0.79 | 0.39 |

Results of traditional DEA model indicates that the companies such as Parsian, Iran Moein and Pasargad are efficient ($E_k$=1) in year 2008 (Table 3). But all of the above companies are not efficient in marketing and investment process simultaneously. Results of the two-stage DEA model shows that the Iran Moein company has the highest overall efficiency with score efficiency of 0.65 ($E_k$=0.65) in year 2008. In marketing point of view the companies such as Razi, Melat and Hafez are efficient ($E_k^1$=1). In investment perspective all of the companies are deficient in year 2008. ($E_k^2 \neq 1$). The efficiency comparison of the insurance companies shows that Melat and Hafez companies are efficient in marketing process during 2007 and 2008. Therefore, the investment weakness is the main reason of overall deficiencies.

Wilcoxon's signed-rank test was used to identify the main reason of weakness between efficiency average of firs stage and second stage in significant level of 0.01. The null hypothesis is confirmed if we compare the statistics value (-1.37) with critical value ($z_{0.01}$=-2.32). Therefore, the investment weakness is the main reason of insurance companies' deficiencies in year 2008.

**Table 3** Efficiency of Iranian private companies in year 2008

| Insurance companies | Traditional DEA model | | | Two-stage DEA model | | |
|---|---|---|---|---|---|---|
| | $E_k$ (model 1) | $E_k^1$ (model 2) | $E_k^2$ (model 3) | $E_k$ (model 4) | $E_k^1$ (model 5) | $E_K^2 = \frac{E_K}{E_K^1}$ |
| Moalem | 0.40 | 0.61 | 0.62 | 0.14 | 0.55 | 0.25 |
| Parsian | 1 | 1 | 0.48 | 0.44 | 0.92 | 0.47 |
| Tosieh | 0.47 | 0.36 | 1 | 0.21 | 0.30 | 0.70 |
| Razi | 0.76 | 1 | 0.54 | 0.37 | 1 | 0.37 |
| Karafarin | 0.31 | 0.42 | 0.47 | 0.16 | 0.38 | 0.42 |
| Sina | 0.45 | 1 | 0.30 | 0.24 | 0.85 | 0.28 |
| Melat | 0.98 | 1 | 0.45 | 0.45 | 1 | 0.45 |
| Iran Moein | 1 | 0.94 | 1 | 0.65 | 0.67 | 0.97 |
| Omid | 0.40 | 0.44 | 0.50 | 0.14 | 0.29 | 0.48 |
| Hafez | 0.63 | 1 | 0.26 | 0.26 | 1 | 0.26 |
| Day | 0.12 | 0.78 | 0.12 | 0.06 | 0.64 | 0.09 |
| Saman | 0.68 | 0.44 | 0.79 | 0.30 | 0.39 | 0.76 |
| Novin | 0.66 | 0.62 | 0.45 | 0.28 | 0.61 | 0.45 |
| Pasargad | 1 | 0.37 | 1 | 0.33 | 0.34 | 0.97 |
| Average | 0.63 | 0.71 | 0.57 | 0.28 | 0.63 | 0.46 |

Results of traditional DEA model indicates that Iran Moein company is efficient ($E_k$=1) in year 2009 (Table 4), but this company is not efficient in marketing and investment process simultaneously. Result of the two-stage DEA model in right side of the table 4 indicates that the Iran Moein company has the highest overall efficiency with score efficiency of 0.54 in year 2009. In marketing point of view the companies such as Melat and Hafez are efficient. In investment viewpoint both of the companies are deficient.

Results showed that Iran Moein efficiency was decreasing from 2007 to 2009 (Tables 2, 3, 4). The reason is that this company only focused in one stage for example marketing or investment each year.

Wilcoxon's signed-rank test was used to identify the main reason of weakness between efficiency average of firs stage and second stage in significant level of 0.01. The null hypothesis is confirmed if we compare the statistics value (-2.29) with critical value ($z_{0.01}$=-2.32). The result indicated that the null hypothesis is confirmed. Therefore, the investment weakness is the main reason of insurance companies' deficiencies in year 2009.

**Table 4** Efficiency of Iranian private companies in year 2009

| Insurance companies | Traditional DEA model | | | Two-stage DEA model | | |
|---|---|---|---|---|---|---|
| | $E_k$ (model 1) | $E_k^1$ (model 2) | $E_k^2$ (model 3) | $E_k$ (model 4) | $E_k^1$ (model 5) | $E_K^2 = \frac{E_K}{E_K^1}$ |
| Moalem | 0.40 | 0.77 | 0.25 | 0.19 | 0.77 | 0.24 |
| Parsian | 0.69 | 0.92 | 0.29 | 0.27 | 0.92 | 0.29 |
| Tosieh | 0.38 | 0.60 | 0.29 | 0.18 | 0.60 | 0.30 |
| Razi | 0.38 | 0.86 | 0.17 | 0.15 | 0.86 | 0.70 |
| Karafarin | 0.32 | 0.52 | 0.24 | 0.12 | 0.52 | 0.23 |
| Sina | 0.40 | 0.79 | 0.22 | 0.16 | 0.70 | 0.22 |
| Melat | 0.66 | 1 | 0.26 | 0.26 | 1 | 0.26 |
| Iran Moein | 1 | 0.54 | 1 | 0.54 | 0.54 | 1 |
| Omid | 0.35 | 0.25 | 0.70 | 0.13 | 0.19 | 0.68 |
| Hafez | 0.99 | 1 | 0.29 | 0.29 | 1 | 0.29 |
| Day | 0.41 | 0.43 | 0.49 | 0.21 | 0.43 | 0.48 |
| Saman | 0.46 | 0.42 | 0.57 | 0.24 | 0.42 | 0.57 |
| Novin | 0.29 | 0.55 | 0.26 | 0.14 | 0.55 | 0.25 |
| Pasargad | 0.48 | 0.39 | 0.57 | 0.22 | 0.39 | 0.56 |
| Average | 0.51 | 0.64 | 0.40 | 0.22 | 0.63 | 0.39 |

## 8 Discussion

Traditional studies in DEA view systems as a whole, ignoring the performance of their internal processes in calculating the relative efficiency of a set of production systems. The deficiencies include the fact that the efficiency score may not properly represent the aggregate performance of the processes of a system. The objective of efficiency measurement is to detect the weak areas so that appropriate efforts can be devoted to improve performance. An issue which is of greater concern to the inefficient DMUs is what factors cause the inefficiency. To answer this question, much effort has been devoted to break down the overall efficiency into components so that the sources of inefficiency can be identified. One type of decomposition focuses on the structure of the DEA model.

Traditional DEA models consider all DMU activities as a black box and ignore the intermediate products. Therefore, the two-stage DEA model was used in this research.

Kao and Hwang [9] measured the efficiency of non-life insurance companies with two-stage DEA model in Taiwan. They showed that there is a significant difference between the marketing efficiency average and investment efficiency average. They indicated that investment sub-process weakness is the main reason of insurance companies' deficiencies. The result of this research is similar to study of Kao and Hwang [9]. A two-stage DEA model is used to measure the dual impacts of operating and business strategies for the Canadian life and health (L&H) insurance industry [17]. His result indicated that the Canadian L&H insurance industry operated fairly efficiently during the period examined (the year 1998). The result also showed that operation and business performances have significantly mutual effects. Therefore, efficiency analysis should be considered simultaneously which is similar to the result of this study that emphasis this issue.

A two-stage DEA model was used for efficiency evaluation of banks [7]. Luo found that the real problem of bank inefficiency is due to marketability efficiency rather than profitability efficiency. However, there is a contradiction between his result and the result of

this paper. Here we found that the investment weakness is the main reason of Iranian private insurance companies' deficiencies in the study period.

## References


1. Kueng, P., (2000). Process Performance Measurement System. Total Quality Management, 11(1).
2. Fortuna, T., (2000). A DEA Model for the Efficiency Evaluation of Nondominated Paths on a Road Network European. Journal of Operation Research, 549-558.
3. Kao, C., (2009). Efficiency decomposition in network data envelopment analysis: A relational model. European Journal of Operational Research, 192, 949-962.
4. Chen, Y., Zhu, J., (2004). Measuring information technology's indirect impact of firm performance. Information Technology and Management, 5, 9-22.
5. Chen, Y., Liang, L., Yong, F., (2006). A DEA game model approach to supply chain efficiency. Annals of Operation Research, 145, 5-13.
6. Kao, C., Hwang, S., (2010). Efficiency measurement for network systems: IT impact on firm performance. Decision Support Systems, 48, 437-446.
7. Luo, X., (2003). Evaluating the profitability and marketability efficiency of large banks: An application of data envelopment analysis. Journal of Business Research, 56, 627-635.
8. Seiford, L., Zhu, J., (1999). Profitability and Marketability of the Top 55 U.S. Commercial Banks. Management Science, 45(9), 1270-1288.
9. Kao, C., Hwang, S., (2008). Efficiency decomposition in two- stage data envelopment analysis: An application to non-life insurance companies in Taiwan. European Journal of Operational Research, 185, 418-429.
10. Chen, Y., Zhu, J., Cook, W. D., (2010). Deriving the DEA frontier for two-stage processes. European Journal of Operational Research, 138-142.
11. Fecher, F., Kessler, D., Pestieau, P., (1993). Productive performance of the French insurance industry. Journal of Productivity Analysis, 4, 77–93.
12. Zha,Y., Liang, L., (2010). Two-stage cooperation model with input freely distributed among the stages. European Journal of Operational Research, 205, 332 -338.
13. Iranian Central Insurance, (2010). financial lists (http://www.centinsur.ir)
14. Cook, W., Liang, L., Zhu, J., (2010). Measuring performance of two stage network structures by DEA: A review and future perspective. Omega, 38,423-430.
15. Sexton, T. R., Lewis, H. F., (2003). Two-stage DEA: An application to major league baseball. Journal of Productivity Analysis, 19, 227–249.
16. Azar, A., Momeny, M., (2008). Statistics and Its Application in Management. SAMT publication,Tehran, Iran, Vol, 2, pp. 439.
17. Yang, Z., (2006). A two-stage DEA model to evaluate the overall performance of Canadian life and health insurance companies. Journal of the Mathematical and Computer Modeling, 43, 910-919.