Using data envelopment analysis model for determining the
efficiency of private insurance subsidiaries in Mashed (Persians)

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Abstract

Efficiency is the most factors in development and growth of economic enterprises. So that achieving the desired level of that is the survival of firms in the competitive environment of today ‘economy. With attention to high importance of insurance for development and growth of country, efficiency of insurance agencies has high importance. Also in this study has paid to evaluate the performance using DEA agents Insurance Corp. Today, the most financial institutions and services in order to evaluate the performance of mathematical models are used in operations research. These models set the unit to consider the input and output indicators and with attentions to the importance and impact of performance on each indicator, total weight of the total weighted inputs to outputs as performance units are calculated to decide the case. DEA model for this study, the required data from 60 agencies were gathered in Mashad. After running the model with the output, in addition to the expected performance of each of the units, i.e. units that efficient representations of the sources of their inputs, outputs were ranked according to need. And finally the image of each agent was calculated inefficiency on the efficient frontier.

Key words: Efficiency; DEA; Insurance.

Abbreviations: CCR - Charns, Cooper and Rhodes; CEM - Cross Efficiency Matrix; DEA - Data Envelopment Analysis; AHP - Analytical Hierarchical Processes; AP - Anderson and Peterson.

Introduction

Insurance is considered as one of the most important branches of the service Sector is considered. In addition, insurance as an economic entity plays an important role in economic, social and political. In fact, insurance with coverage possible damages that resulting from various economic activates insurance investment incentives with itself plays an important role in the country development (Hadian & Azimi, 2004). Playing these roles, has been cause changes in the insurance sector that including sight increased in insurance companies. So, from 2001 with changes in country structure, from state to a non- governmental, governmental was allowed began to operate non- governmental organizations private investment in the insurance companies in free zones. Because of this reason, nowadays private sector participation is seen more in the field of economic activates that had important consequences. Among the consequences is insurance competition between insurer to attract customers and development in insurance markets. So, it is natural that insurance companies to operate in this competitive market, while improving their operations, must consider their competitors activates, and with continuing compare them with their self-gain correct understanding of their position (Mohammadi & Hosseinzadeh, 2005).

Due to stated factors use precise criteria for evaluating insurance companies appear to be necessary. One of the best criteria for evaluating performance is performance measure. In fact with evaluating the performance we understand how a single unit has used set of facilities and how performance.

There are various methods for measuring the efficiency of firms. Two of these method are preferred than nonparametric methods. Because in this method does not need to choose function from and there is no limited for output number. Actually,
this method following covering charts that taken all active firms in a particular industry and uses of that as a criterion for efficiency calculation. Data Envelopment Analysis and free distribution hull is the non-parametric model that in this article data envelopment analysis model is used (Fortuna, 2000).

In continue the paper is organized as follow, the second section briefly review data envelopment analysis model. The third section is over viewing the research conducted about research subject, applied research models are described in section four and in section V and VI, respectively are mentioned to study research methods and results.

**Data Envelopment Analysis**

In DEA method it is essential the production function or frontier production function as comparison of standard indicators. First time Farrell introduction some production function in 1957 with using a system that consisting of two inputs and one output. He able to measure the efficient frontier based on mathematical methods and according to the firm's production distance of production efficiency border (Mehreghan & shafiee, 2004).

Then, Charns, Cooper and Rhodes were generalized Farrell nonparametric method with using mathematical program for a system with multiple inputs and outputs. The model assuming constant returns to scale, to be known as the CCR. Finally Banker, Charns, Cooper CCR method was generalized CCR method for the case of variable returns to scale the proposed model is became known to BCC based on the first letters of their names (Bowlin, 2002).

**Calculates the efficiency with data envelopment analysis**

With using data envelopment analysis model, could evaluated power of homogeneous decision making units in covering inputs to outputs. Homogeneous decision units are which have the similar action that received input vector as \( X = (x_1, ..., x_m) \), produce output vector as \( Y = (y_1, ..., y_s) \). If we decide that the number of decision making units or DMU is equal \( n \) it means \( DMU_1, DMU_2, ..., DMU_n \) that these DMU use \( m \) type of input to reach \( s \) type of output and if corresponding weight of output \( r \) and I specified and defined as \( u_r \) and \( v_i \) could show CCR model as below with input field- oriented (Charnes, 1978).

\[
\begin{align*}
\text{Max} & \quad E_p = \sum_{r=1}^{s} u_r y_{rp} \\
\text{s.t.} & \quad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \quad j = 1, 2, ..., n \\
& \quad \sum_{i=1}^{m} v_i x_{ip} = 1 \quad u_r \geq \varepsilon \quad v_i \geq \varepsilon
\end{align*}
\]

Proposed model is a linear programming problem, the unknowns are \( u = (u_1, ..., u_s) \) and \( v = (v_1, ..., v_m) \) that shows the weight of outputs and inputs. The number of unknowns are \( (m+s) \), constraints number are \( (n+1) \). Since \( n \geq 3(m+s) \) and critical factor in the linear programming problems are independent adverbs hence it can be made dual that is called covering form with assumption \( s_i^{-} (i = 1, ..., m) \) and \( s_r^{+} (1, ..., s) \) covering model is: (Jahanshahloo, 2008).

\[
\begin{align*}
\text{Min} & \quad \theta_p - \varepsilon (\sum_{r=1}^{s} s_r^{-} + \sum_{i=1}^{m} s_i^{-}) \\
\text{s.t.} & \quad \sum_{i=1}^{m} \lambda_i x_{ij} + s.r^{-} = \theta_p x_{ip} \quad i = 1, ..., m \\
& \quad \sum_{j=1}^{s} \lambda_j x_{rj} - s.r^{+} = y_{rp} \quad r = 1, ..., s \\
& \quad \lambda_j, s_i^{-}, s_r^{+} \geq 0 \quad \text{all } j, i, r
\end{align*}
\]

To be more precise, in such models with using mathematical programming and considering the place of units, the production possibility set is obtained; this set is independent of the study direction, (the output or input oriented) and highlights the border of product possibility. This line
indicates the best position to convert input to output and called efficient. Indeed the efficient frontier is a convex combination of efficient units, therefore, each firm is located on the efficiency frontier is efficient and otherwise, inefficient. For measuring the points that are not on the effective border an effective agent or combination of two or more efficient firms as the reference set and pattern introduce. Since this combined firm will not necessarily exist, known as a peer unit for under study unit. In other words, a reference for a non-efficient firm can be real estate agent, or in general, is a virtual enterprise (Seiford, 1996).

Performance Evaluation in insurance industry

Both parametric and non-parametric methods can be used for performance evaluation and performance measurement. In some of the research such as what Fetcher and colleagues conducted both DEA and SFA will used to measure performance of different insurance companies and results show a high correlation between the models.

In another study, Cummins and Zi were compared three methods of DEA, SFA and DFA. The results showed that the efficiency scores in both econometric and mathematical program have significant correlation with the conventional practice of measuring performance.

The research was conducted to evaluate the performance of insurance companies with regard to Indicators such as firm size and..... For example, Cummins and colleagues investigated the technical efficiency of the American insurance in three sizes small, medium and large. The results express that large firm’s efficiency was 90% and small and medium size have 80% and 88% efficiency. In addition, medium and small firms also benefited from economies of scale or in Fenn and his colleague’s research investigated two indicators of firm size and market structure on the inefficiency of domestic life and non life insurance in 14 European countries. In addition investigating indicators began to measure the efficiency of various insurance companies. For example, Stephen Diacon compared performance of insurance companies in five European countries. Thus, he considers capital and personnel resources as inputs and investment income as the output and results showed that Britain, Germany, Holland, France, Switzerland and Italy have the highest efficiency. In next steps for evaluating the performance of insurance companies took advantage of network structure. Thus the two approaches were used for production and investment. It means that output in the first stage is used as input on the second stage such as Wu and his colleague study that used two approaches, production and investigation. Inputs in the production approach was consider as general operating expenses, expenses, capital stock, net insurance claims incurred and output, including premiums and net income. The investment approach: the input consists of investor interest in bonds and real estate investments in the stock. Results showed that there are significant interaction between factors of production and investment. The lowest correlation coefficient 86% between net investments in stacks property and net premium and the highest rate is 98% between incurred and total investment.

Applicable models

According to the Fig.1, we see that the efficient frontier is resulted of convex combination of DMU’s. Points are located above the efficient frontier with the lack of efficiency and the points below the efficient frontier are not obtainable. For example, A is inefficient, thus reducing both inputs.
\( x_1 \& x_2 \) (the radius) technical inefficiency can be removed at the same time that this state called. But there is another type of inefficiency that some (not all inputs or outputs) are has inefficient behavior that this type of non performance called mix inefficiency. Like point F although it is located on the efficient border, but more than units C used input \( x_1 \) but efficient use of inputs, but it has created as the same size of output C. This problem in efficiency study is known as name of (Input - Slack). If the model is considered based on the product maximum, a problem as name of output slack occurs. To eliminate this inefficiency it is necessary to reduce input \( x_1 \) without any change in input \( x_2 \) and output. To eliminate this inefficiency is necessary to input \( x_1 \) change in input or output \( x_2 \) be reduced.

There is a problem to evaluate the efficacy of using CCR, BBC models that the lack of additional input and output are not considered directly in the objective function. In fact there is distinction between technical inefficiency and combination but in the non-radial measure, surplus inputs and shortage of outputs are considered simultaneously to achieve the efficient frontier in the objective function. The objective function for F in CCR model is 1 based it was located on efficient border but in the non-radial such as SBM model 1 will not resulted. This is due to surplus of input factors in the CCR model is not in the objective function and presented as a working unit but in SBM model, this factor surplus is considered in objective function and unit F is an inefficient unit (Cooper et al., 2007).

Non-radial model include, mass model, SBM and Russell. That Russell model in 2006 reviewed by Cooper and colleagues the Shadow, as was the case and expressed as below (Cook & Seiford, 2008).

\[
\begin{align*}
\text{Max} & \quad \frac{1}{s} \sum \phi_i - \frac{1}{m} \sum \theta_i \\
\text{s.t} & \quad \sum \lambda_j x_{ij} \leq \theta_i x_{i0}, \quad i = 1, \ldots, m \\
& \quad \sum \lambda_j y_{jr} \geq \phi_j x_{r0}, \quad r = 1, \ldots, s \\
& \quad \sum \lambda_j = 1 \\
& \quad \lambda_j \geq 0, 0 \leq \theta_i \leq 1, \phi_j \geq 1
\end{align*}
\]

**Research Methodology**

Statistical society in this study included 60 parsian insurance agencies that issuance all types of insurance in order to be able to trust the result of DEA model, minimum number of decision makers unit must calculated from following equation.

Number of decision making units \( \geq 3(X + Y) \)

In the above equation, \( X \) is number of inputs and \( Y \) is number of output. In this study with inspired of other functional studies that performed in this field and insurance expert's comments about impact and importance of each of the indicators cases as followed were examined as studied variables. Input includes:

- \( x_1 \): General and administrative expenses: These costs include all costs related to administrative activities, including office supplies such as stationery, paper and...., Depreciation of buildings and equipment, administrative, legal and auditing expenses, salaries of administrative staff.

- \( x_2 \): Cost of sales: is includes all costs related to the sale is to deliver products to customers. But with considering that services are not part of the intangible goods, does not include transportation cost and expenses have been considered include advertising, publicity and marketers fees. Advertising and publicity are included such factors as public announcement, newspapers, magazines, brochures, Catalog, conference and etc...Marketer's fees: the amount paid to marketers (the people that in addition of visitor (Manufacturing limited product) service and
Receiving price at same time) and sell skills must have ability such as concepts mastering, attracting order, and counseling) in exchange for their services.

\[ x_3 \] This indicator is calculated according to number, education and experience work of representative's employees and has been used in analysis. Thus, for each agent according to the number of personnel, education and work experience points is considered and finally to obtain a score for each representative's employee, agency personnel's scores were added together. In related to rating type according to agency official statement, maximum numbers of employee in each agency have estimated 5. In related work experience, since private insurance companies started to operate from 80th, and maximum work experience during his service is 30 years. In this study, the maximum work experience for individuals serving in the Persian insurance industry has been 20 years. The education has been rated according to level of university as follow:

Diploma=1  Associate Degree=2  BA=3
MA=4

Staff rated= number * work experience * Education

\[ x_4 \] Business location of representatives of: This criterion is determined according to different regions of the city that are not the same in terms of potential insurance. For this purpose, agencies monthly rental has considered thus, higher rental prices, meaning the commercial situation of that agency is better and vice versa. It is noteworthy that the goal is counting economic situation and its effect on level of insurance agent sales.

\[ x_5 \] Equity investment of 89. Investments in inventories 89 (end) - Investments in inventories 88 = Equity investment of 89

And output, including:

\[ y_1 \] The number of insurance issued by representative: Included all number of insurance policies issued in different fields such as fire, cargo, and life......

\[ y_2 \] The amount of issued insurance policies: is multiplied Price in the number of issued insurance policies in different fields.

\[ y_3 \] Total compensation paid by compensation unit for each Representative: This indicator has been calculated by sum of the total compensation paid by a representative in all fields.

\[ y_4 \] The amount of compensation paid: This indicator will be considered as a collection of amounts that a representative insured for Redress of Insured (or lost) and returned to his pre-accident conditions in different areas of insurance field.

\[ y_5 \] Net income of represent: Amounts of the fees that agency has received of the insurance company after deduction all of costs. If the damaging ratio is less than the Receive Premiums, Insurance will pay an amount as profit sharing in the benefits to agent. Since Minimum number of decision units for analysis are: Number of decision units = 3(5+5) =30. Considering that the Representatives units are 60 and the minimum numbers of decision-making units for analysis are 30, so from this sample size there is ability to extract reliable results.

It is Necessary to mention that in considered output damage is an undesirable one. And the general attitude in units' performance evaluation is that reduced inputs and increased output can be improved performance, but in practice must be noted that Organizations are not always looking to maximize output and minimize input. Because output and inputs are can be desirable or undesirable. For example numbers of defective goods are undesirable output that to improve performance must be reduced.

In this study the number and amount of damages paid will be considered as an undesirable output, that for solving the can be used this method. Thus the undesirable output are considered as input and Such as inputs affected with the aim of minimizing...
the model, so seven input variables and three output variables have been considered. As mentioned earlier it was necessary to be considered weight limitations for measuring the efficiency of the unit that have several inputs and output.

Indeed, with placing weights on relevant model, is determined that decision making units are placed where on the border and to reach efficiency border what combination of inputs and output is to be selected. In this study, to obtain the weight importance on the considered indicators, first with designing a questionnaire and completed that by several active agencies, importance degree of indicators to each other in related to efficiency of each of the Agencies were of performance in relation to each other agencies were Specified, then, with using the figures related to fazi data weight limitations of input and output were calculated and finally according to representatives target (maximum output and minimizing input) among DEA models, Russell model with output orientation was selected as most suitable model for performance evaluating and Gams calculations were done software.

Results

According to relevant model represents that amount of their efficiency obtained one effective and other unit that amount of their efficiency is more than one is inefficient. In this study, of 60 agencies that evaluated, 25 agencies have allocated 100% efficiency to themselves. It should be noted that inefficient units can be rating by obtaining efficiency score. But in DEA models due to the lack of a complete ranking between efficient units, compare possibility of mentioned units with each other do not provide simply. Because of this, it is necessary to ranking between efficient units. Several methods have been proposed for ranking efficient units which can mention as follow: Cross Efficiency Matrix (CEM), Data Envelopment Analysis / Analytical Hierarchical Processes (DEA/AHP) and Anderson and Peterson (AP) that in this study Anderson and Peterson model has been used.

In Anderson and Peterson model, under study unit is excluded from the evaluation. And because inefficient units, are not effective in formation of efficient border, their removing will not affect the efficiency border so their efficiency will not change even in ranking model with AP attitude, but removing efficient units will cause to changing in efficiency border. In fact, changing rate of removing an efficient unit will be Criterion to ranking between efficient units. Efficiency number that dedicated to the efficient units in the full ranking AP model is equal to one or more than. So in this model, every decision maker unit that will achieve more efficiency number will have higher performance between efficient units (Martic, Milan & Gordana Savic, 2001).

\[ \text{Min } \sum v_i x_{ip} + u_o \]
\[ \text{st. } \sum x_i y_{ij} - \sum y_i y_{ij} + u_j \geq 0 \quad j = 1,...,n \quad j \neq p \]
\[ u_j, y_{ip} = \frac{1}{s} \]
\[ u_j \geq 0 \quad v_i \geq 0 \]

At the end with using picture points, best operation situation that inefficient agencies should with achieve that level of outputs achieved efficient
frontier, was calculated. For example, among 60 examined agencies, were investigate three agencies. Agency A with an efficiency score 1 that is an effective agent was calculated based on Anderson and Peterson model and allocate rank 18 to itself. Agency B has efficiency score 9/64 and rank 33. As it can be seen in Table 1 agency A that is efficient, there is no difference between point output Image and primary output, but agency B for reaching to efficiency border required increase number of insurance issued of 382 cases to 446 cases per year, amount of insurance issued of 189/72 to 220/73 and agency’s net income from 22/45 to 36/92 until able to achieve required efficiency. It is worth to mention as it can be seen in picture point in some of the Agencies to reach efficient border, changing all three output is not necessary, but also with changing in two or even one output could achieve this goal, such as C agency that with increasing amount of insurance and agency's net income could achieve to efficiency border.

Conclusion

One of the advantages of DEA model with considering the amount of input and output of all under study units is highlighting efficient and inefficient units that as its result researcher could apply necessary changes to make efficient non-efficient units. With regard the role and influence of inputs in creating outputs and considering that the goal of agency is to increase output the first proposes to increase the agency's efficiency in relation to increasing number of issued insurance is that Agency's office should be in areas which have higher population concentration and have a better financial situation. Although this will increase the rental value that is in conflict with primary aim to reduce inputs. But with considering that these areas have more potential for customer acceptance this advantage is more worthy than increase in rental price.

The second factor in reducing the efficiency of agencies is increasing General and official expenses which the main of them is salary of employees. Investigations was indicate that applying more than two people in agencies, not just created great expenses for them but also reduced their efficiency. For this reason it is recommended that, agencies instead of applying more staff focus on training them and in this way increase their workforce productivity.

The third factor is advertising and its influence on agencies's efficiency. Results showed that advertising has direct effect on increasing issued insurance and consequently has agencies's efficiency. But should be noted that agencies usually have limited financial facilities and therefore can not use costly advertising. For this reason it is recommended using marketing strategies such as marketing communication that is considered to contact with interest groups especially stable connection and turning them into loyal customers or creative and innovative marketing strategies, Task Force (partisan) marketing or total quality marketing.

Fourth factor is damage payment that according to research results this indicator is considered as effective factor in inefficiency but it can be used for higher sales. Many factors are involved in issuing insurance and possible damages but with speeding up the payment of compensation to customers, can increase sense of trust and satisfaction in them towards considered insurance’s brand and in next steps increased profitability with sell of other types of insurance to customers.

References


