Efficiency Analysis Of Non-Life Insurance Companies In Terms Of Underwriting Process With Data Envelopment Analysis

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Abstract

Efficiency analysis with DEA, attract quite few attention in finance sector. In literature all over performance of companies examined in general. However analysis of the activities performances carried out by the company can be researched with data envelopment analysis. In this paper, in order to analyze the effectiveness of underwriting processes for insurance companies primarily inputs and outputs are determined. These input and output variables were obtained from annual reports of the 12 insurance companies operating in Turkey. Efficiency analysis were made by using models of CCR and BCC with utilizing EMS program. Thus, according to both models efficient and inefficient companies were determined. In addition, scale efficiencies of insurance companies which were evaluated were also examined. Finally, by using specific input and output variables analysis of insurance companies which has been developed to see performance of companies relative to single activity.

Keywords: Data Envelopment Analysis, Insurance, Efficiency, Underwriting

Introduction

Insurance can be defined from the viewpoint of several disciplines. For instance the Commission on Insurance Terminology of the American Risk and Insurance Association has defined insurance as follows. Insurance is the pooling fortuitous losses by transfer of such risks to insurers, who agree to indemnify insureds for such losses, to provide other pecuniary benefits on their occurrence, or to render services connected with risks (Rejda, 2008: 19). Here the concept of pooling means putting people who have the same risk sharing the losses by the entire group. Fortuitous refers to an unforeseen and unexpected way revealed in the concept of loss. Another important concept in definition is the transfer of risk. Pure risk is transferred from the insured to the insurer, which is in a stronger financial position. Insurance is a complicated mechanism so it is consequently difficult to define. However in simple terms it has two fundamental characteristics. First of all this mechanism transfers or shifts risk from one individual to a group, secondly it shares losses on some equitable basis, by all members of group (Vaughan & Vaughan, 2013: 34).

According to the definition of insurance, risks are undertaken with premiums collected by individuals that are exposed to the same risk. In the case of losses in order to compensate the loss insurance companies have to put aside technical reserves and commentate underwriting process carefully. Therefore underwriting process is crucial for insurance companies.

Underwriting is the function of evaluating the subject of insurance which will be person, property, profession, business, or other entity determining whether to insure it. The underwriter must apply company standards to each applicant and based on these standards, ascertain whether the application represents an acceptable risk (“Insurance Underwriting”, 2001: 4). However in practice companies do accept risks that have different risk profile but the acceptance of those risks is done under different conditions, like charging an extra premium, applying exclusions (Macedo, 2009: 1). Consequently, while assessment of risks some factors are considered. For instance, in life insurance policies age, sex, health history, financial condition, personal habits may include as a factor in the underwriting process whereas type, value of property, construction materials, potential hazards, security measures in non-life insurance policies.

Brockett, Cooper, Golden, Rousseau & Wang (2004) examined the efficiency of insurance companies by using solvency, claims payment ability and return on investment as outputs via data envelopment analysis. As a result the effect of solvency on efficiency was shown. Hwang & Kao (2006) applied the model that measuring managerial efficiencies in two sub-processes independently by Seiford & Zhu (1999) to 24 non-life insurance companies. In first stage performance was measured by marketability whereas in second stage performance was measured by profitability. Wu, Yang, Vela & Liang (2007) put Hwang & Kao (2006) paper to next stage by developing simultaneously assessing both production and investment performance of insurers. Lin, Yang & Liou (2007) evaluate non-life insurance companies in Taiwan in terms of service innovation via data envelopment analysis. Writers tried to see how efficiencies change with the innovation of e-commerce in insurance industry. Eventually when e-commerce applied there wasn’t significant change in efficiency scores.

Similarly with the Hwang & Kao (2006), again Kao & Hwang (2008) proposed a modified conventional model which consider whole process as two relational stage. But this model is more reliable in measuring efficiency and is capable of identifying the cause of inefficiency more accurately. Chen, Cook, Li & Zhu (2009) said that the model which is proposed by Hwang & Kao (2006) has a major drawback because of applicability to only constant returns to scale (CRS) situations. Therefore Chen et al. developed an additive decomposition approach that involves overall efficiency based on weighted sum of stages. Wu & Zeng (2011) calculated technical, pure technical, scale and super efficiency by using LİNDO software and SAS software on behalf of supplying a tool for comparing in the field of economic management. They evaluate life insurance companies in China. Consequently the importance of underwriting quality, service awareness and business structure was stated. Huang & Eling (2013) analyzed non-life insurance companies in Brazil, Russia, India and China in order to captures cross-cultural differences such as political and economic environment. As a result they found out that environment affects the efficiency of non-life insurers. Zimková (2015) extends the radial DEA models to non-radial model (SBM) and super efficiency model. These models was applied in 13 Slovak insurance companies. The recent study of Biener, Eling & Wirfs (2016) analyzed Swiss insurance companies in the life, property/ casualty and reinsurance sector in terms of productivity and efficiency by means DEA. In this paper unbalanced panel dataset was used which covers the period of 1997-2013. The results of this study validated and help to better understand the determinants of productivity in insurance sector.

Insurance Sector in Turkey

Foreign subsidiaries are dominated in insurance sector in Turkey. The first insurance company which has only domestic capital was established in republic period. Afterwards, on favor of economic developments the number of insurance companies has increased (Turgutlu, Kök & Kasman, 2007: 89). In the sector as of 2014, 63 insurance, pension and reinsurance companies have been operating, of which 38 are non-life insurance, 5 are life insurance and 19 are pension and one is reinsurance companies. Table 1 shows the market shares of insurance sector in terms premium production in Turkey. It is obvious that non-life insurance companies is the major part of insurance sector. In addition over the years the percentage of market share in non-life insurance gained strength.

Table 1: Market Shares of Life and Non-Life Insurance Sector (%)

Market Share	2010	2011	2012	2013	2014	2015
Non-Life	84.56	84.35	86.33	85.99	87.4	87.9
Life	15.44	15.65	13.67	14.01	12.6	12.1
Total	100.00	100.00	100.00	100.00	100.00	100.00

Data Envelopment Analysis (DEA)

The DEA technique has been developed to analyze questions of general substitutability between outputs and inputs. This method is a distribution free (non-parametric) in which efficiency frontier is determined by the data (Bates, Baines & Whynes, 1996: 1443). DEA was described as a non-parametric frontier method that uses linear programming techniques to discover the frontier firms and construct a convex piece-wise linear surface or frontier over these firms by Diacon, Starkey & O'Brien (2002).

DEA was suggested by Charnes, Cooper & Rhodes in 1978, then Banker, Charnes & Cooper proposed a modified DEA model in 1984. With the help of these suggested models performance can be evaluated. Evaluated units which has common inputs and outputs is called Decision Making Units (DMU). By means of DEA relative efficiency of each DMU's can be calculated in order to make a comparison. As a result, this method provides also reference units for inefficient ones. A reference unit is traditionally found in DEA by projecting the inefficient DMU radially to the efficient surface (Korhonen, 1997: 1).

There are three main phases carrying out an efficiency study by means of DEA are the following (Golany & Roll, 1989: 238):

- Definition and selection of DMU to enter the analysis.
- Determination of input and output variables which are relevant and suitable for assessing the relative efficiency of DMU's.
- Application of the DEA models and analysis outcomes.

The advantage of DEA is that this method is applicable for all types of data as inputs and outputs. Therefore data based on various scales can be used on behalf of calculating efficiencies. However the number of DMU's should be at least three times the total number of inputs and outputs (Paradi, Yang & Zhu, 2011: 325).

$$n \geq \max \{m*s, 3*(m+s)\} \quad (1)$$

n = The number of DMU's

m = The number of input

s = The number of output

DEA Models

The two main DEA models are CCR proposed by Charnes et al. and BCC developed by Banker et al.. These models provide a variety of ways of assessing the efficiency of DMU's in order to improve the planning and control of these activities (Charnes et al., 1978: 443). CCR and BCC can be generated as input oriented or output oriented. Input oriented model specifies the most appropriate values of inputs in order to product the most efficient value of outputs, whereas in output oriented model vice versa. In other words, input orientation means that DMU is not efficient if it is possible to decrease any input without augmenting any other input and without decreasing any output (Charnes, Cooper & Rhodes, 1981: 669). In this study input oriented model will be considered.

The model that Charnes et al. (1978) was proposed consider constant return to scale (CRS) while evaluating the efficiencies. Input oriented CRS model can be seen as below (Charnes et al., 1978: 430):

$$\text{Max } h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \tag{2}$$

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_r x_{ij}} \leq 1; \quad j = 1, 2,..., n$$

$$u_r, v_i \geq 0; \qquad r = 1, 2,..., s; \quad i = 1, 2,..., m$$

Here the y_{rj}, x_{ij} are the known outputs and inputs of the j^{th} DMU. u_r, v_i are the weights of respectively output and input variables. The objective function measure efficiency of each DMU by obtaining the maximum ratio of weighted outputs to weighted inputs. So as to make the input oriented model more simple and soluble non-linear type replace with primal linear model (Ray, 2004: 30).

$$\text{Max } h_0 = \sum_{r=1}^{s} u_r y_{r0} \tag{3}$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_r x_{ij} \leq 0 \quad j = 1, 2,..., n$$

$$u_r, v_i \geq 0; \qquad r = 1, 2,..., s; \quad i = 1, 2,..., m$$

Obtained efficient DMU will be references to inefficient units. In order to determine efficient reference sets dual CRS model can also be utilized

(Cooper, Seiford & Zhu, 2011: 9). The dual model of CRS can be seen as below:

$$\theta^* = \text{Min } \theta_0$$

$$\sum_{j=1}^{n} x_{ij}\lambda_{ij} \leq \theta x_{i0} \quad \text{i = 1, 2,..., m} \tag{4}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_{j} \geq y_{r0} \quad \text{r = 1, 2,..., s}$$

$$\lambda_j \geq 0 \qquad \text{j = 1, 2,..., n}$$

Primal model in Eq. (3) refers to as the envelopment form, whereas the dual model in Eq. (4) is the multiplier form (Charnes, Cooper, Lewin & Seiford, 1994: 26). In equity (4) λ_j is the weight of j[th] DMU. Because of this model is a constant returns to scale $\lambda_j \geq 0$. θ_0 refers to the total efficiency score which should be 1 if DMU is efficient.

The model that explained above considers total efficiency which is composed by technical and scale efficiency. Therefore in order to see why DMU is inefficient technical and also scale efficiency score should be calculated. At this point another model which is called BCC or Variable Returns to Scale (VRS) point out (Banker et al, 1984: 1085).

$$\text{Max } h_0 = \sum_{r=1}^{s} u_r y_{r0} - u_0 \tag{5}$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - u_0 - \sum_{i=1}^{m} v_r x_{ij} \leq 0$$

j = 1, 2,..., n $\quad$ u_r, $v_i \geq 0$; $\quad$ r = 1, 2,..., s; $\quad$ i = 1, 2,..., m

In this primal BCC model u_0 specifies whether returns to scale is increasing or decreasing. The dual BCC model is expressed as (Cooper, Seiford & Tone, 2007: 91):

$$\theta^* = \text{Min } \theta_B$$

$$\sum_{j=1}^{n} x_{ij}\lambda_{ij} \leq \theta x_{i0} \quad \text{i = 1, 2,..., m} \tag{6}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_{j} \geq y_{r0} \quad \text{r = 1, 2,..., s}$$

$$e\lambda_j = 1 \qquad \text{j = 1, 2,..., n}$$

$$\lambda_j \geq 0$$

As it can be seen above the only difference of BCC model from CCR model is the constraint of being convex. In DEA literature dual models of these two is utilized as primal models (Cooper et al., 2007: 91).

If any DMU is efficient according to BCC model, it isn't possible to say DMU is also efficient as to CCR model exactly. However in addition to BCC model, if scale efficiency is exist, it can be said that DMU is efficient precisely in terms of CCR model (Coelli, 1996: 18). The calculation of scale efficiency is shown as:

$$\text{Scale Efficiency} = \frac{Q_{CCR}}{Q_{BCC}} \qquad (7)$$

Determining Inputs and Output Variables

In DEA literature generally production and intermediary approach are used so as to compare units. But these approaches evaluate the general performance of each DMU. Because of taking main sources as inputs, performances can be evaluated in terms of production. The production approach treats insurers as institutions that provide various products and services to their customers. Therefore they collect premiums from clients and redistribute most of the funds to those policyholders who sustain losses (Yang, 2006: 913). In the literature the most common output variables used for risk pooling/bearing services are either premiums or the present value of losses incurred (Huang & Eling, 2013: 581). In addition labor expenses, equity capital and debt capital are generally considered as inputs (Cummins, Misas & Zi, 2004: 3131).

This study differentiates in determining input and output from the other studies that generally use the same input and output variables. While determining input and output variables decision makers should focus on the activity that are going to inspect. Since underwriting process will be evaluated, net written premiums, the number of policies, claim paid and insurance technical provisions are used as inputs and outputs. In simple way insurers take premiums from their clients in order to pay incurred losses. In addition insurance companies have to consider all insured people whether they will face losses or not. Therefore so as to recompense all unforeseen losses undertaken insurers put aside insurance technical provisions. Consequently while incurred losses consist of policies that insurers undertaken, insurance technical provisions show the power of written premiums. As a result, the number of policies and written premiums are input variables, whereas insurance technical provisions and losses paid are output variables.

The Performance Analysis of Non-life insurance Companies in terms of Underwriting

In this study 12 non-life insurance companies operated in Turkey was taken as DMU in order to evaluate their performance in terms of underwriting process. 12 companies that are determined constitute 68.73 % market share of non-life insurance sector in terms of premium production in Turkey. On account of comparison between years (2010-2014) period was used. Input and output variables were taken from financial reports of insurance companies. Although there are lots of DEA models, CCR, BCC and scale efficiencies were calculated in order to determine the cause of inefficiencies. Table 2 shows the result of efficiency scores based on constant returns to scale.

Table 2: CCR Efficiency Scores (%) (2010-2014)

DMU	2010	2011	2012	2013	2014	Average	Ranking
DMU1	76.08	76.14	96.52	100.00	100.00	89.75	4
DMU2	78.46	67.52	85.00	74.64	72.18	75.56	8
DMU3	78.70	78.84	97.74	100.00	100.00	91.06	3
DMU4	72.85	68.15	61.11	28.06	53.46	56.73	11
DMU5	82.51	63.75	63.76	60.00	71.50	68.30	10
DMU6	74.68	74.91	77.80	76.84	78.34	76.51	7
DMU7	74.47	77.25	73.19	75.38	87.62	77.58	6
DMU8	53.80	40.43	42.19	35.82	41.56	42.76	12
DMU9	85.22	81.63	92.17	75.14	65.91	80.01	5
DMU10	79.17	82.90	66.26	65.60	67.53	72.29	9
DMU11	86.30	100.00	100.00	100.00	100.00	97.26	2
DMU12	100.00	100.00	100.00	100.00	97.67	99.53	1

As it can be seen from Table 2, the average of all DMU's CCR efficiency scores (total efficiency scores) cannot reach 100%. The least efficient insurance company is DMU8 while the most efficient one is DMU12 as of average efficiency scores. In 2010 only one insurance company was efficient. In year 2011 and 2012 DMU11 was also efficient. Although two more insurance company were efficient in 2013, the most of them remained same in terms of underwriting process. In last term three insurance companies (DMU1, DMU3, DMU11) were efficient. As a result with the help of efficiency scores managers or decision makers can easily notice the situation of company among the others in sector.

Table 3: BCC Efficiency Scores (%) (2010-2014)

DMU	2010	2011	2012	2013	2014	Average	Ranking
DMU1	100.00	100.00	100.00	100.00	100.00	100.00	1
DMU2	81.23	73.92	86.09	74.97	72.29	77.7	6
DMU3	100.00	100.00	100.00	100.00	100.00	100.00	1
DMU4	82.49	80.74	66.01	32.90	100.00	72.43	8
DMU5	86.68	69.97	66.20	62.19	87.16	74.44	7
DMU6	78.83	78.19	79.27	79.48	95.61	82.28	4
DMU7	78.83	86.64	74.71	76.01	87.73	80.78	5
BCC Efficiency Scores (%) (2010-2014) (Continued)							
DMU8	59.73	45.23	45.88	38.40	51.27	48.10	9
DMU9	100.00	100.00	100.00	100.00	100.00	100.00	1
DMU10	85.20	90.75	70.72	70.11	100.00	83.36	3
DMU11	90.27	100.00	100.00	100.00	100.00	98.05	2
DMU12	100.00	100.00	100.00	100.00	100.00	100.00	1

In Table 3, BCC efficiency score are shown. In literature BCC efficiency scores are called as technical or pure technical scores. This score is consisted of CCR efficiency scores, therefore the number of technical efficient companies is higher than the number of total efficient companies. DMU1, DMU3, DMU9, DMU12 are the most efficient insurers, whereas DMU8 is an inefficient insurance company among the others. In addition DMU1, DMU3 and DMU9, DMU12 have shown a stable performance in terms of underwriting between the years 2010-2014. The number of efficient insurance companies increased within 5 years. In the beginning of period 4 insurers are efficient, whereas in the year 2014 7 insurance companies reached 100% efficiency.

Table 4: Scale Efficiency Scores (%) (2010-2014)

DMU	2010	2011	2012	2013	2014	Average	Ranking
DMU1	76.08	76.14	96.52	100.00	100.00	89.75	8
DMU2	96.59	91.34	98.73	99.56	99.85	97.21	3
DMU3	78.70	78.84	97.74	100.00	100.00	91.06	7
DMU4	88.31	84.41	92.58	85.29	53.46	80.81	11
DMU5	95.19	91.11	96.31	96.48	82.03	92.23	6
DMU6	94.74	95.81	98.15	96.68	81.94	93.46	5
DMU7	94.47	89.16	97.97	99.17	99.87	96.13	4
DMU8	90.07	89.39	91.96	93.28	81.06	89.15	9
DMU9	85.22	81.63	92.17	75.14	65.91	80.01	12
DMU10	92.92	91.35	93.69	93.57	67.53	87.81	10
DMU11	95.60	100.00	100.00	100.00	100.00	99.12	2
DMU12	100.00	100.00	100.00	100.00	97.67	99.53	1

Table 4 demonstrates the scale efficiencies of insurance companies. Scale efficiency scores help to decision makers in order to comprehend the reason of inefficiency in CCR model. If a decision making unit is inefficient according to CCR model, while BBC efficiency score is 100%, it can be said that inefficiency derive from scale inefficiency. Based on this although DMU1, DMU3 and DMU9 are efficient in terms of BCC model, scale inefficiencies as mentioned Table 4. As a result the least efficient insurers are DMU9 and DMU4 in the sense of scale efficiency.

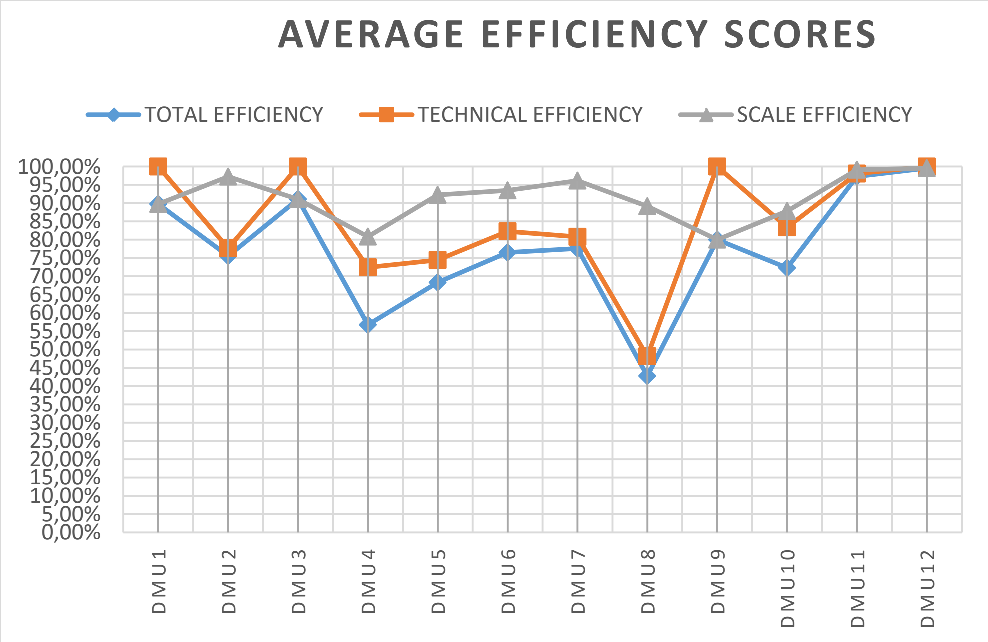

Figure 1: Average Efficiency Scores (2010-2014)

Average efficiency score are viewed more comprehensible in Figure 1. It is evident that DMU8 is the most inefficient insurer. As a summary in order to be efficient in terms of underwriting process, each insurance company have to predict the amount of losses that they undertook correctly. Otherwise insurers will have trouble about compensate these losses. Thereby it can be said that DMU8 couldn't foresee forthcoming losses. As a result of it, they put too much money as insurance technical provisions rather than invest in financial instruments. In other words, being efficient from the point of underwriting is not only about paying less compensation than the amount of taking premiums or not about minimum incurred losses. Being efficient means distribute risks to the great number of insureds and allocate sufficient amount of money based on the amount of losses incurred.

Conclusion

The literature of performance analysis there are lots of methods that evaluate efficiency of decision making units. However the most preferred one is Data Envelopment Analysis. By means of DEA, decision makers can compare units in terms of relative efficiencies. However banks and insurance companies are taken as DMU in generally, evaluation criteria doesn't change. Analysis which were done before considered the same financial indicators as inputs and outputs. But these financial indicators can evaluate the general financial performance of DMU's. Although efficiency of activity performance play a key role in comparison, very few studies focused on activity of companies was made in literature.

In this study underwriting performance of 12 non-life insurance company were analyzed via EMS program. Input and output variables were identified distinctly from the other studies. Written premiums and the number of policies were taken as inputs, whereas losses paid and insurance technical provisions were taken as outputs. Data was collected from financial reports of companies. In addition 5 years (2010-2014) were examined in terms of total, technical and scale efficiencies by means of DEA. Variables used in this study can guide decision makers in order to decide whether the related company is relatively efficient or not. For suggestion to further study various activities of financial institutions can be evaluated by determining relevant variables with related activities.

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