EVALUATION OF THE EFFICIENCY OF NATIONAL INSURANCE MARKETS USING A TWO-STAGE MODEL OF DATA ENVELOPMENT ANALYSIS

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Abstract

This paper compares the efficiency of national insurance markets. Efficiency is assessed on the basis of the efficiency score, expressed in two-stage models of data envelopment analysis, which belong among the simple serial network DEA models. Application of the method allows to assess the efficiency of partial processes that make up the whole process. The first partial process within the insurance activities is intended to maximize the income from insurance premiums while trying to minimize costs of insurance claims and operating expenses. The second partial process aims to invest available funds in order to generate the highest possible return on investment. The paper also examines the differences in the efficiency of national insurance markets in the post-communist countries, with particular emphasis on efficiency in the Czech Republic. For comparisons employs statistical methods for testing hypotheses. The group of countries that joined the EU after 2000 have a greater arithmetic average of the efficiency score than the other analyzed national insurance markets

Key words: data envelopment analysis, efficiency, live insurance market.

JEL code: G22, C52

Introduction

The insurance market of Europe is a major segment of a global insurance industry, and as such plays an important role in the development of the economy of Europe. The share of premiums collected in European countries in 2013 was almost 35.16% of the worldwide premiums and was larger than the share of Asia and North America. The value of worldwide premiums has increased since 2004 by more than 31% (Insurance Europe, 2013). Creation of a single EU insurance market played an important role in the development of the insurance market in Europe. Uniform legal framework that is created within that single market contributes to improving the dynamics and provides better protection for the individual subjects of the insurance market, especially clients of insurance companies. One of the basic principles, the principle of a single license, allows insurance companies of each Member State to easily operate on the territory of another Member State.

Free movement of capital between EU countries for the purpose of investment is permitted within the single European area. The European insurance market for life insurance is growing faster than the insurance market for general (non-life) insurance. From 2012 to 2013, worldwide life premiums rose by 3.1% while the worldwide non-life premiums grew by only 0.9%. The share of life insurance premiums in total premiums written worldwide exceeds the share of non-life insurance premiums. National insurance markets for life insurance in the EU vary greatly in size and pace of development. For example, in countries such as France or the United Kingdom there is a long tradition of insurance and insurance markets are big. Conversely insurance markets for life insurance, for example, in Latvia or Iceland are very small. Insurance markets for life insurance in Slovakia and the Czech Republic represent smaller insurance markets. For a long time they formed a single unit. The insurance market for life insurance in the Slovak Republic has a larger share on insurance premiums than non-life insurance and its development is dynamic. From 2012 to 2013, life premiums increased by 5.8%. The insurance market for life insurance in the Czech Republic has a smaller share on premiums as non-life insurance. Its share has been gradually increasing but is still below the EU average.

Insurance markets vary not only in size but also in efficiency. Efficiency is not directly determined by the size of the market. Small insurance markets may (or may not) be more efficient than large insurance markets. Our objective is to examine whether premium life insurance markets in countries that joined the EU after 2000 are less efficient than other national insurance markets. To compare the efficiency we use the two-stage models, which belong among the network DEA models.

1 Literature Review

According to Kao (2014), the first scientific paper dedicated to a network model where the whole process is divided into two subprocesses published Charnes et al. (1986). They examined the efficiency of policy evaluation and management of Army recruiting activities. Seiford and Zhu (1999) published the first study applying two-stage DEA models within the financial system. The authors evaluated the efficiency of 55 US commercial banks in the two sub processes. Inputs in the first subprocess (profitability) include the assets, employees, stockholder's equity, the output of the first subprocess as well as inputs of the second subprocess are revenues and profits. The outputs of second subprocess (marketability) are EPS (earnings per share), market value and total return to investors. Two-stage model proposed by Chen and Zhu (2004) is applied in evaluating the efficiency of banks. Their

analysis also focuses on information technology investment. Two-stage model proposed by Kao and Hwang (2008) is applied in evaluating the efficiency of non-life insurance companies in Taiwan. Inputs in the first subprocess include operation expenses and insurance expenses. Outputs in the first subprocess and inputs in the second subprocess comprise of direct premiums written and reinsurance premiums. Outputs in the second subprocess are underwriting profit and investment profit. Chen, Liang and Zhu (2009) address the relationship between the model of Chen and Zhu (2004) after elimination of constraints $\sum_{j=1}^{n}\mu_j = 1,\ \sum_{j=1}^{n}\lambda_j = 1$ and the model Kao and Hwang (2008). Zhu (2009) presents an overview of two stage models and uses Solver in Microsoft Excel in expressing the degree of efficiency in practical tasks. Yang (2006) examines assessment of the efficiency of life insurance in two models - production model and investment model.

2 Research Goal and Methodology

2.1 Research Goal

Our work is aimed at analyzing the efficiency of national insurance markets for life insurance in Europe, using a two-stage DEA model. The aim of this paper is to analyze the efficiency of national insurance markets for life insurance, focusing on the differences observed between the groups of national insurance markets conditional on accession to the EU. The variables entering the analysis are divided into inputs and outputs. Inputs in the first subprocess include net operating expenses and life benefits paid. Gross written life insurance premiums is output of the first subprocess that serves as the input in the second subprocess. Output of the second subprocess is investment income. Data were drawn from a database of company Insurance Europe, which brings together national associations of insurance companies from 34 countries. The data used are from the database of Insurance Europe - Life technical accounts from 2011 (Insurance Europe, 2011), and from Statistics N˚50 European Insurance in Figures – dataset (Insurance Europe, 2013). The latest available published data are for 2010 but not for all member states of the association. Consequently, our analysis uses the available data from 2010 for 18 national insurance markets for life insurance in the EU. The necessary data for the Slovak Republic were not disclosed. Data on the Czech Republic were available. The analyzed insurance markets for life insurance in Europe include seven national insurance markets in countries that joined the EU after 2000, namely Bulgaria, Czech Republic, Estonia, Latvia, Malta, Poland, Slovenia. Four national insurance markets are in countries that are in

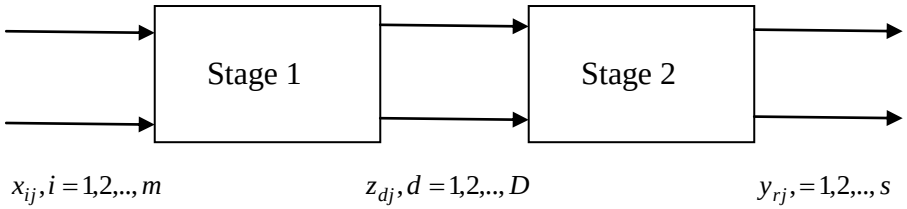
the EU since 1958 (founding members). These are Belgium, France, Italy and Netherlands. Complete list of analyzed national insurance markets for life insurance is in Table 2.

2.2 Methodology

Efficiency is evaluated by the efficiency score expressed by basic two-stage DEA model. Basic two stage model belongs to the simple network models. According to Färe et al. (1996) the main reason for the use of network models in assessing efficiency is the fact that the traditional models for DEA efficiency measurement are based on thinking about production as a "black box". Inputs are transformed in black box into outputs and the operations of the component processes are ignored. The problem of "black box" can be addressed via network models.

Chen and Zhu (2004) proposed a model that expresses the level of efficiency of a process that breaks down into two subprocesses (stage 1, stage 2). Two-stage process is shown in Figure 1.

Fig. 1: Two-stage process



Source: (Chen, Cook and Zhu, 2010)

The outputs of the first subprocess serve as inputs in the second subprocess. Chen and Zhu (2004) proposed model under the assumption of variable returns to scale (it includes constrains

$$\sum_{j=1}^{n} \lambda_j = 1, \ \sum_{j=1}^{n} \mu_j = 1).$$

We assume that we have n homogeneous DMUs and we monitor in the first subprocess m inputs x_i and D outputs z_d which are inputs of the second subprocess and in the second subprocess we have n subjects with s outputs y_r,, and then assuming variable returns to scale the model expressing efficiency of the k-th DMU takes the form

$$\min_{\alpha,\beta,\lambda_j,\mu_j,\tilde{z}} \ w_1\alpha - w_2\beta \qquad (1)$$

s.t.

(stage 1)

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le \alpha x_{ik},\ i = 1,..,m, \tag{2}$$

$$\sum_{j=1}^{n} \lambda_j z_{dj} \ge \tilde{z}_{dk},\quad d = 1,..,D, \tag{3}$$

$$\lambda_j \ge 0,\quad j = 1,...,n, \tag{4}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{5}$$

(stage 2)

$$\sum_{j=1}^{n} \mu_j z_{dj} \le \tilde{z}_{dk},\ d = 1,..,D, \tag{6}$$

$$\sum_{j=1}^{n} \mu_j y_{rj} \ge \beta y_{rk}, \qquad r = 1,..,s, \tag{7}$$

$$\mu_j \ge 0,\quad j = 1,...,n, \tag{8}$$

$$\sum_{j=1}^{n} \mu_j = 1, \qquad \text{(Chen and Zhu, 2004).} \tag{9}$$

Kao and Hwang (2008) proposed model under the assumption of constant returns to scale. Output-oriented model is expressed as

$$\theta_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}},\ \theta_j^1 = \frac{\sum_{d=1}^{D} w_d z_{dj}}{\sum_{i=1}^{m} v_i x_{ij}},\ \theta_j^2 = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{d=1}^{D} \tilde{w}_d z_{dj}}, \tag{10}$$

$v_i, w_d, \tilde{w}_d, u_r$ are unknown non-negative weights.

$$\min \frac{\sum_{i=1}^{m} v_i x_{ij_0}}{\sum u_r y_{rj_0}},$$

$$s.t.\quad \theta_j^1 \le 1,\quad \theta_j^2 \le 1,\ \text{for all j}, \tag{11}$$

$$w_d = \tilde{w}_d \ \text{for all d.} \qquad \text{(Zhu, 2009).} \tag{12}$$

Chen, Liang and Zhu (2009) show that the constant returns to scale version of the Chen and Zhu is equivalent to the output-oriented Kao and Hwang model. The optimal α, β in Chen and Zhu model do not represent the efficiency scores of individual stages under the

CCR condition. In fact, β represents the overall efficiency of the two-stage process. (Zhu, 2009).

3 Results and Discussion

At the beginning of analysis we report the descriptive statistics of inputs and outputs. Values of respective descriptive statistics - mean, median and standard deviation are reported in Table 1.

Tab. 1: Descriptive statistics (EUR millions)

	Mean (EUR millions)	Mean (EUR millions)	Median (EUR millions)	Standard deviation	Coefficient of variation (%)
	All states	EU Accession after 2000	All states		
Net operating expenses	1587.20	314.73	661.93	2946.29	185.63
Benefits paid	14830.50	1064.57	5733.00	25148.65	169,57
Gross written premiums	20966,06	1662.29	7727.00	37278.30	177.81
Investment income	10849.26	376.46	2190.12	18134.65	167.15

Source: own processing in Statistica

Arithmetic mean for all the analyzed indicators (inputs and outputs) is greater than the median. Variability expressed by the coefficient of variation is greatest for net operating expenses, and it is smallest for the investment income. The arithmetic mean of all indicators of countries which joined the EU after 2000 is significantly smaller than the arithmetic mean of indicators for all countries. The greatest difference is in the arithmetic mean of investment income of countries that joined the EU after 2000 - it is 28.82 times smaller.

Next, we express our overall efficiency scores from two-stage process. To express the efficiency score we use the relations 1-4 and 6-8 in Chen and Zhu model. β represents the overall efficiency of the two-stage process. Table 2 presents values of the efficiency score. Reported efficiency score is in the output oriented model. If DMU is efficient it has an efficiency score equal to one and lies at the efficiency frontier. The higher is the value of the efficiency score (greater than one), the more is the DMU remote from the data envelopment. The arithmetic mean of the reported values of the efficiency scores for all analyzed countries is 7.33%. The median value is 6.23%. The arithmetic mean of the reported values of the efficiency scores in the EU countries that joined the EU after 2000 is 11.69%.

Tab. 2: Efficiency score in the two-stage model

	Overall efficiency – CCR
Austria	8.99
Belgium	4.13
Bulgaria	7.29
Czech Republic	5.97
Denmark	1.05
Estonia	11.13
Spain	4.49
Finland	1.34
France	4.65
Greece	9.88
Iceland	6.49
Italy	5.72
Latvia	20.27
Malta	6.63
Netherlands	4.31
Poland	21.15
Sweden	3.33
Slovenia	9.37

Source: own processing in Microsoft Excel

The arithmetic mean of the reported values of the efficiency score in the EU countries that joined the EU in 1958 is 4.70%. The arithmetic average of the efficiency score for other EU countries is 8.5%.

Reported values indicate that no national insurance market for life insurance is efficient. The lowest efficiency score reached the insurance market for life insurance in Denmark. The second lowest efficiency score is reported for the insurance market in Finland. The efficiency score of the insurance market for life insurance in the Czech Republic is below the arithmetic mean of the efficiency score of all countries. The Czech Republic has the lowest efficiency score of the insurance market for life insurance of the countries that joined the EU after 2000 i.e. it enjoys the best position in this group. The highest efficiency scores reached the insurance market for life insurance in Poland and the insurance market in Latvia. Other countries with above-average values of efficiency score are Estonia, Greece, Slovenia and Austria.

The three highest levels of efficiency scores are obtained in countries that joined the EU after 2000. This led us to examine whether it can be concluded that there is a statistically significant difference in the probability distribution of the degree of efficiency of national insurance markets that are members of the EU after 2000 and other national insurance markets. Based on the reported efficiency scores we use the non-parametric Mann-Whitney U test to test at a significance level of 0.05 two-sided null hypothesis H_0 versus alternative hypothesis H_1. H_0: there is no statistically significant difference in the probability distribution of the efficiency scores of the national insurance market for life insurance in countries which are members of the EU since 2000 and the efficiency scores of the other analyzed national insurance markets for life insurance. H_1: there is statistically significant difference in the probability distribution of the efficiency scores of the national insurance market for life insurance in countries which are members of the EU since 2000 and the efficiency scores of the other analyzed national insurance markets for life insurance.

The values of U-statistics and corresponding p-values are shown in Table 3. The Mann-Whitney U test indicates at the significance level of less than 0.05 that there is a significant difference in the probability distribution of the efficiency scores. The average efficiency score of the national insurance markets for life insurance in countries that joined the EU after 2000 is statistically significantly different from the average efficiency score of the other analyse national insurance markets for life insurance.

Tab. 3: Hypothesis test for independent samples

	Mann-Whitney U	P-level
joined the EU after 2000 versus other	8	0.0057
joined the EU in 1958 versus other	14	0.1371

Source: own processing in Statistica

In the next step, we focused on the countries which are founder members of the EU. We have tested H_0: there is no statistically significant difference in the probability distribution of the efficiency scores of the national insurance market for life insurance in countries which are founder members of the EU and the efficiency scores of the other analyzed national insurance markets for life insurance.

H_1: there is no statistically significant difference in the probability distribution of the efficiency scores of the national insurance market for life insurance in countries which are founder members of the EU and the efficiency scores of the other analyzed national insurance markets for life insurance.

The values of U-statistics and corresponding p-values are shown in Table 3. The results of Mann-Whitney U test do not reject the null hypothesis. We cannot conclude that the average efficiency score of national insurance markets for life insurance in countries which are founder members is statistically significantly different from the average efficiency score of the other analyzed national insurance markets for life insurance.

Conclusions

In this paper we addressed the analysis of the efficiency of national insurance markets for life insurance in EU countries. We used a basic two-stage DEA model, which takes into account the fact that the entire process of insurance is divided into two sub-processes. It approximates the efficiency score of the insurance market relative to the values of other insurance markets analyzed. From the reported values of the efficiency score in the two-stage model we can conclude, that the group of countries that joined the EU after 2000 have a greater arithmetic average of the efficiency score than the other analyzed national insurance markets, and that there is statistically significant difference in the average efficiency score of national insurance markets for life insurance in these new member states and the average efficiency score of insurance markets for life insurance in other analyzed countries.

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