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Productivity Evaluation of Iranian Insurance Industry: A Non-Parametric Malmquist Approach

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Abstract
The paper studies the changes of total factor productivity for all Iranian Insurance companies for the period 2003-2009. In order to measure the changes in productivity, data envelopment analysis (DEA) method is applied. DEA method is used to estimate output oriented Malmquist productivity index. To determine effective factors on the total factor productivity growth of insurance companies tobit regression is used. The results of the study confirm the positive effect of liberalization policy adopted by government on productivity growth. The results also indicate that dimension and the field of activity have significant positive effect on productivity growth.

Keywords: Productivity; Malmquist TFP Index; Iranian Insurance Industry; Efficiency
JEL classification: C43, C44, C61, G21

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1. Introduction

The efficiency of insurance companies has been received a huge amount of attention in the empirical studies up to now.Efficiency and productivity are major issues in contemporary Iranian economy due to more pressure that competition has exerted on prices since the adoption of privatization and allowing for the entry of new companies into almost all markets.The objective of the studyis tomeasure the Malmquist productivity index of the Iranian insurance companies by using the data envelopment analysis (DEA) approach. The index measures productivity growth for all the selected companies during the period of time. And also the study is going to determine the effective factors on productivity changes of the insurance companies over the period of 2003–2009.The paper follows the tradition of analyzing national markets[1] and departs from the tradition of analyzing multi-country markets. Among the nonparametric benchmarking techniques, data envelopment analysis (DEA),has been the most commonly used in recent research in insurance market. The study analyzes comparative efficiency of all Iranian insurance companies and evaluates total productivity with the Malmquist index. To the author's Knowledge, the study is the first article to examine the relative efficiency of all Iranian insurance companies. The paper adopts a two stage approach; in the first stage, Malmquist index is estimated. In the second stage, the index is regressed on economic characteristics of each company.

The paper is organized as follows: firstly we present the empirical literature review. The section includes some advantages and disadvantages of different approaches to the subject.Secondly the theoretical framework of the study is presented.The model used in the study is supported by the framework presented in that section. Data and results are reported in the next section. The econometric model will be estimated; results will be discussed. At the end of the study we make final concluding remarks.

2. Empirical literature review

Two important approaches to analyze efficiency quantitatively are the econometric frontier and data envelopment analysis (DEA).Themain advantage of the econometric approach lies in its ability to shift the deleterious effect of measurement error away fromestimates of efficiency.Data envelopment analysis also has advantages. The approach permits the use of multiple inputs and outputs. The approach does not impose any functional form on data and also it does not make any distributional assumptions for the inefficiency term.

1. Fecher et al. (1993); Gardner and Grace (1993); Fukuyama (1997); Cummins and Zi (1998).

As a relevant study, we can pay attention to the study of Mahlberg and Url (2003). They analyzed Austrian insurance industry with the use of two DEA models. As a first step they used input oriented CCR model and also BCC model. They used four inputs (number of employees, liquid investment, gross technical provision and reinsurance premium) and four outputs (market share, profit, total investment income and premium issued) to make the models. As the second step, they estimated Malmquist productivity index.

Diacon et al. (2002) studied the relative efficiency of 450 European insurance companies. They applied two stages approach. As the first step, they estimated efficiency scores with a VRS DEA model. They used four inputs including total operating expenses net of reinsurance commissions, total capital, total technical reserves and total borrowings from creditors. They also used three output including insurance net earned premiums, long term insurance net earned premiums and total investment income. In the second step, they estimated a Tobit regression. The main conclusion of the study is that the most efficient insurers are those that specialize in particular market.

Noulas et al. (2001) studied some Greek non-life insurance companies. They applied DEA method and used two inputs (including expenses and payment to insurers) and two outputs (including premium incomes and revenue from investment activities). They concluded that the industry is highly inefficient, with considerable differences between insurance companies.

Cummins and Zi (1998) studied the efficiency of the U.S life insurance industry. They applied econometric frontier models and DEA models (CRS – constant return to scale model, VRS – variable return to scale model, NIRS – non increasing return model and FDH – free disposal hull DEA model). They used six outputs includingindividual life insurance benefitpayments, group life insurance benefit payments, individual annuities benefitpayments, group annuities benefit payments, accident and health insurance benefitpayments and additions to reserves. They also used three inputs including quantity of labor,quantity of financial capital and quantityof material.

Fukuyama(1997)studied the efficiency of 25 Japanese insurance companies with a Malmquist index. He focused on ownership structure (mutualand stock insurance companies) and on economic conditions (including expansion andrecession). He used two outputs including insurance reserves and loans. They also used three inputs including asset value of the company premises, internal personnel and sales representatives. He estimated and analyzed the correlations between the different efficiency measures associated with the Malmquist index.

Fecher et al. (1993) studied the French insurance industry for 84 life and 243 non-lifecompanies. They used a DEA and a parametric Cobb-Douglas model. They estimated DEA model in three versions, including aggregate gross premiums,gross premiums in three branches (civil liability, fire-property and accident-health) andgross premiums in auto and non-auto branches. In the case of life insurance, the netreturns on financial investment serve as an additional output, along with gross premiums. They used the following variables as inputs; wage bill and a composite input consisting of various outlays such as capital consumption, purchase of equipment and supplies. They estimated econometric model with one output, gross premium, while the same inputsused as in the DEA model.

3. Theoretical framework

The study applies the efficient frontier approach; using the Malmquist productivity index based on output oriented DEA.Data Envelopment Analysis is a mathematical programming approach for characterizing the relationshipsamong multiple inputs and multiple outputs. The approach initiated by Charnes et al. (1978). It is a nonparametric approach, which does not require a priori functional specification of the unknown technology.DEA has usuallybeen applied to analyzing the relative productive efficiency of a decision making unit(DMU), performing similar tasks in an industry that consumes multiple inputs to produce multiple outputs.If both the input and the output are above the efficiency margin, then the DMU is considered efficient. Likewise, if the input and the output fall within the efficiency margin, then the DMU is considered as an inefficient unit.The Malmquist productivity index, which measures productivity change over time, was first introduced by Malmquist (1953) as a quantity index for use in the analysis of consumption of inputs. The index has been frequently used in many studies because the index allows for changes in productivity to be broken down into changes in technical efficiency and changes in technological efficiency.The Malmquist Productivity Index can be calculated using distance functions.Distance functions allow for the representationof a multi-input and multi-output technology without assuming any behavioural assumptions such as cost minimization or profit maximization.The index can be estimated using either parametric(stochastic frontier analysis) or non-parametricmethods (DEA). Fare et al. (1997) illustrated thatthe distance functions of a Malmquist index can be estimated using the DEA technique. Therefore, the MPI may be considered parametric or non-parametric, based on the method that is chosen forestimating the distance functions. Distance functions can be input or output orientated. If P(x), the output set for the production technology, is defined as follow;

$$P(x) = \{y : x \text{ can produce } y\}$$

Then the output-orientated distance function can be written as:

$$d_O(x,y) = \min\left\{\delta : \left(\frac{y}{\delta}\right) \in P(x)\right\}$$

δ has a value of between 0 and 1. The closer the unit to the frontier, the larger the δ. A value of 1 means that,given a fixed input, the output cannot be increased any more, i.e. (x,y) belongs to the production frontier and the unit is efficient. The Malmquist index measures the total factor productivity change by calculating the change in the distance of a unit in two time periods (period s and period t) relative to a common frontier. The output-orientated Malmquist index, with reference to period s, is defined as the ratio of two distance functions, as shown below:

$$M_o^s\left(x^s, y^s, x^t, y^t\right) = \frac{d_o^s\left(x^t, y^t\right)}{d_o^s\left(x^s, y^s\right)}$$

The subscript o denotes the orientation (output oriented) and the superscript s denotes that the frontier of period s is being examined. As mentioned before the Malmquist index measures thechange in the distance of the unit in the two periods relative to the frontier of period s. The index with reference to period t can similarly be written asbelow:

$$M_o^t\left(x^s, y^s, x^t, y^t\right) = \frac{d_o^t\left(x^t, y^t\right)}{d_o^t\left(x^s, y^s\right)}$$

Since the choice of the reference period is arbitrary, Malmquist index is usually defined as the geometric mean of the two indices.

$$M_o\left(x^s, y^s, x^t, y^t\right) = \sqrt{M_o^s M_o^t}$$

Equivalently the above equation can be written as:

$$M_o\left(x^s, y^s, x^t, y^t\right) = \frac{d_o^t\left(x^t, y^t\right)}{d_o^s\left(x^s, y^s\right)}\left(\frac{d_o^s\left(x^t, y^t\right)}{d_o^t\left(x^t, y^t\right)}\frac{d_o^s\left(x^s, y^s\right)}{d_o^t\left(x^s, y^s\right)}\right)^{0.5}$$

The first ratio on the right-hand side of above equation measures the catch-up effect (efficiency change) and the phrase inside the brackets measures the frontier shift effect (technical change). A value of more than one for Malmquist index and each of its components means thatprogress has occurred; a value of less than one represents a regress. While a value of 1 means that no change has occurred (during the period of time) in the level of productivity or its components.

In this study, data envelopment analysis is used to estimate the distance functions. The approach is chosen because of its flexibility compared with

the parametric approach.The distance function of unit i in time t,relative to the frontier of time t, $d_o^t\left(x^t, y^t\right)$; can be found by solving the following linear programming problem:

$$\left(d_o^t\left(x_{i,t}, y_{i,t}\right)\right)^{-1} = \begin{array}{l} Max\ \varphi \\ \lambda Y_t \geq \varphi y_{i,t} \\ s.t \quad x_{i,t} \geq \lambda X_t \\ \lambda \geq 0 \end{array}$$

Where$x_{i,t}$and $y_{i,t}$are input and output vectors of unit i in time t. $\mathrm{X_t}$ and $\mathrm{Y_t}$ are input and output matrices at time t,comprised of the input and output vectors of all units. The above problem is an output oriented CCR model and the value of distance function $\left(1/\varphi\right)$ is actually the CCR efficiency score of the unit. To find inter-temporal distance functions, such as, $d_o^s\left(x_{i,t}, y_{i,t}\right)$; another DEA model such as the following model can be used:

$$\left(d_o^s\left(x_{i,t}, y_{i,t}\right)\right)^{-1} = \begin{array}{l} Max\ \varphi \\ \lambda Y_s \geq \varphi y_{i,t} \\ s.t \quad x_{i,t} \geq \lambda X_s \\ \lambda \geq 0 \end{array}$$

To obtain accurate measures of total productivity change and its components over time, the CRS (constant return to scale) assumption is necessary. Grifell-Tatje and Lovell (1995) usedan example to show that Malmquist index does not provide correct measures of total productivity change when variable returns-to-scale (VRS) are present.

4. Data and results

In order to estimate frontier, Inputs and outputs should be identified. Several criteria can be used in the selection of inputs and outputs. The first one is availability of data and the second one is the literature survey to ensure the validity of research. The study used both criteria to select inputs and outputs. To estimate the production frontier, we used panel data for the years 2003–2009, obtained from the central insurance of I.R. Iran on 16 insurance companies. The insurance companies that are considered in this study and their performance are presented in Table (1).

Table (1) The Performance ofinsurance companies in 2009

Insurers	Premiums issued (billion IRR) incurrent Rial	Claims Paid (billion IRR) in current Rial	Market Share (%)
Iran	21341.3	15817.8	46.17
Asia	5567.6	4237.6	12.05
Parsian	3242.3	1908.2	7.01
Alborz	3071.1	1837.6	6.64
Dana	2936.1	1963.3	6.35
Moalem	1863.0	746.4	4.03
Mellat	1664.8	1300.3	3.60
Karafarin	1319.0	495.6	2.85
Sina	1172.6	794.0	2.54
Razi	860.2	518.9	1.86
Tosea	786.8	146.1	1.70
Novin	771.0	232.8	1.67
Day	652.3	404.0	1.41
Saman	476.2	149.7	1.03
Pasargad	474.0	121.5	1.03
Mihan	22.2	1.4	0.05

Source: The central Insurance of I.R. Iran

The top four companies in 2009 are Iran, Asia, Parsian and Alborze. These four companies have the control of more than seventy percent of insurance market. To get accurate measures of Malmquist index, we respected the DEA convention that the minimum number of companies should be greater than three times the number of inputs plus output (82 observations > 3(1+2)). Outputs are variables that measure the results of the insurance activity such as profit and claims paid to policy holders and input is premiums issued.

As mentioned before the Malmquist index can be estimated in several ways. In this study we estimated output oriented Malmquist productivity index, based on DEA. In output-oriented models, DEA seeks to identify technical inefficiency as a proportional decrease in input usage. The estimated output oriented CRS Malmquist index for the insurance companies over the period of time is presented in table (2).

Table (2) Output oriented CRS Malmquist index

Company	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009
Iran	1.00000	1.00000	1.00000	1.00000	1.00000	1.01443
Asia	1.04427	1.00000	1.02950	0.95164	0.97386	1.02798
Alborz	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
Dana	1.15888	0.93038	1.00000	1.00000	1.00000	1.00000

Moalem	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
Parsian	0.98212	1.00000	1.00000	1.00000	1.00000	1.00000
Tosea	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
Razi	0.98798	1.00000	1.00000	1.00000	1.00000	1.00000
Karafarin	0.99000	1.00000	1.00000	1.00000	1.00000	1.00000
Sina	0.97967	1.00000	1.00000	1.00000	1.00000	1.00000
Mellat	0.97831	1.00028	0.98664	1.00000	1.00000	1.04136
Day	-—	-—	0.98406	1.00000	1.00000	1.00000
Saman	-—	-—	0.97525	1.00000	1.00000	1.00000
Novin	-—	-—	0.96551	1.00000	1.00000	1.00000
Pasargad	-—	-—	-—	0.98835	1.00000	1.00000
Mihan	-—	-—	-—	-—	-—	0.96796

Source: Author's estimation

5. Determinants of the efficiency of insurance companies

The study applies the Tobit regression method to examine the hypothesis that insurance company efficiency is determined by the liberalization policy adopted by Iranian government in recent years, the dimension of activity measured by size and the field of activity including life and non-life insurance. The following Tobit model is used;

$$\theta_{i,t} = \beta_1 Size_{i,t} + \beta_2 Ent_{i,t} + \beta_3 Life_{i,t} + u_{i,t}$$

Where θ represent output oriented Malmquist index (TFP). Size is a dummy variable equal to 1 for top largest insurance companies. The variable captures the role of size in efficiency. Ent is a dummy variable equal to 1 for companies that entered the market after liberalization in insurance market. The variable captures the role of increased competitiveness in efficiency. Finally, Life is a dummy variable equal to 1 for companies dealing mostly in life insurance and 0 elsewhere. The variable can capture the role of efficiency in life insurance companies. The estimated coefficients are presented in table (3).

Table (3) Censored Tobit model (dependent variable (θ))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
SIZE	0.816412	0.055715	14.65330	0.0000
ENT	0.954798	0.032580	29.30580	0.0000
LIFE	0.334534	0.111070	3.011927	0.0026

According to the estimation results, the Malmquist index is positively related with the Size variable. It support the notion that dimension has a positive effect on efficiency. The Malmquist index also is positively related

with the ENT variable. It means that liberalization and entering new companies had a positive effect on efficiency. In other words it shows the fact that increased competition environment has enhanced productivity and efficiency in the industry. Finally, the results indicate that Malmquist indices are positively related with the Life variable. It shows that those companies that the majority of their insurance activity are life insurance are more efficient compared to other companies. To examine how the model fit the data, Wald test is carried out. The F statistic (419.9) rejects the joint hypothesis that all coefficients are not significantly different from zero at the 1% level.

Table (4) Wald Test: Null Hypothesis: $\beta_1 = \beta_2 = \beta_3 = 0$

Test Statistic	Value	d.f.	Probability
F-statistic	419.9166	(3, 78)	0.0000
Chi-square	1259.750	3	0.0000

6. Concluding remarks

The study examined the changes in total productivity for all Iranian insurance companies between 2003 and 2009. Insurance industry witnessed liberalization policy during the period of time. According to the policy barriers to entry decreased thus new insurance companied entered the industry and number of incumbents increased dramatically. Malmquist productivity index is used to measure changes in productivity during the period of time. To examine the significance of factors such as size, liberalization policy and the field of activity on productivity changes a tobit regression is used. The results of tobit regression indicate the fact that all of these factors have positive and significant effect on productivity growth during the period of time. In other words, we conclude that liberalization policy adopted by Iranian government in recent years had a positive effect on the productivity of insurance companies. It seems that the policy has improved productivity because of better competitive environment in insurance industry. The results also show the fact that dimension (size) and field of activity are effective factors on productivity. It means that life insurance companies enjoy more productivity growth than nonlife insurance companies. It also means that size has played an important role in productivity improvement during the period of time. In other words the results of tobit regression show that bigger companies has enjoyed more productivity improvement during the period of time. The major policy implication of this research is that increased competition resulting from the liberalization policy has increased the efficiency of the companies operating in the previously protected market. Therefore it seems that more liberalization can boost competitive environment and increase the number of incumbents in the industry. The situation ultimately can improve the productivity of insurance companies in future. Another policy implication of the research is that any financial support for small companies to increase the size of operation can improve the productivity of such companies.

References

Adnan Kasman and Evrim Turgutlu (2009), "Total Factor Productivity in the Turkish Insurance Industry", Vol.16 No.2: 239 247.

Carlos Pestana Barros, Milton Nektarios and A. Assaf (2010), "Efficiency in the Greek Insurance Industry", *European Journal of Operational Research,* No. 205: 431 436.

Cummins, J.D. and Zi, H. (1998), "Comparison of Frontier Efficient Methods: An Application to the US Life Insurance Industry", *Journal of Productivity Analysis,* 10(2): 131–152.

Diacon, S.R., K. Starkey and C.O. O'Brien (2002), "Size and Efficiency in European Long-term Insurance companies: An International Comparison", *Geneva Papers on Risk and Insurance*, No. 27: 444–466.

Fare. R., E. Grifell-Tatje, S. Grosskopf. and C.A.K. Lovell (1997), "Biased Technical Change and Malmquist Productivity Index", *Scandinavian Journal of Economics*, 99(I): 119-128

Fecher, F., D. Kessler, S. Perelman and P. Pestieu (1993), "Productive Performance of the French Industry", *Journal of Productivity Analysis,* 4: 77–93.

Fukuyama, H. (1997), "Investigating Productive Efficiency and Productive Changes of Japanese Life Insurance Companies", *Pacific-Basin Finance Journal,* 5(4): 481–509.

Gardner, L.A. and M.F. Grace (1993), "X-efficiency in the US Life Insurance Industry", *Journal of Banking and Finance,* 17: 497–410.

Grifell-Tatje E. and C.A.K Lovell (1995), "A Note on the Malmquist Productivity Index", *Economics letters*, No. 47, pp. 169-75.

Hans, Bjurek (1996), "The Malmquist Total Factor Productivity Index", *Scandinavian Journal of Economics*, 98(2): 303-313.

Mahlberg, B. and T. Url (2003), "The effects of the single market on the Austrian insurance industry", *Empirical Economics,* 28: 813–838.

Milton Nektarios and Carlos Pestana Barros (2010), "A Malmquist Index for the Greek Insurance Industry", *The Geneva Papers*, 35: 309 324.

Nancy Y. C. Kong and Jose Tongzon (2006), "Estimating total factor productivity growth in Singapore at several level using data envelopment analysis", *Applied Economics*, 38: 2299 2314.

Noulas, A.G., T. Hatzigayios, J. Lazaridis and K. Lyroudi (2001), "Non-parametric production frontier approach to the study of efficiency of non-life insurance companies in Greece", *Journal of Financial Management and Analysis,* 14(1): 19–26.