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A study on efficiency and productivity of Indian non-life insurers using data envelopment analysis

G. S. S. Bhishma Rao*, R. Venkateswarlu

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Abstract This paper talks about the measurement of efficiency and productivity of non-life insurance firms in India. This study is focused on twelve private non-life insurance firms and four public sector non-life insurance firms of India in the period 2008-09 to 2012-13. Data Envelopment Analysis (DEA) coupled with Malmquist productivity Index is used in measuring the efficiency as well as productivity of the Indian non-life insurers. The study attempts to use commission plus management expenses and capital as input parameters and net premium and investment income as output parameters. The technical efficiency of these firms is measured and analysed through CRS and VRS methods.

Keywords: Non-life Insurers**;** Efficiency, Data Envelopment Analysis (DEA), Malmqu- ist Index, India.

1 Introduction

Insurance business in India had been monopolised by public insurers till the year 2000. The move towards economic change in the early 1990s and the Malhotra committee's suggestions in 1993 in the insurance sector finally resulted in the formation of the Insurance Regulatory and Development Authority (IRDA) Act of 1999. The foremost responsibility of IRDA is to bring the relevant changes in insurance business to protect the policyholder's interest and suggest improvements and new ideas for growth of insurance sector. As per the Malhotra committee's recommendations, private firms are allowed to do insurance business in India. Insurance market of India has been opened to foreign companies with a cap on the shareholding at 26% in the joint venture with Indian companies.

As a start, good number of private insurance companies has started business which has brought the competition in this sector. Presently there are four public and twenty three private non-life insurance companies operating in India. Considering the high risky nature of the insurance business, efficiency measurement is critical and an important aspect of the business performance.

* **Corresponding Author. (✉)**
E-mail: bhishma.gajavelli@gmail.com (G.S.S.Bhishma Rao)

G.S.S.Bhishma Rao
Research Scholar, GITAM School of International Business, GITAM University, Visakhapatnam, Andhra Pradesh, India

R.Venkateswarlu
Professor, GITAM School of International Business, GITAM University, Visakhapatnam, Andhra Pradesh, India

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2 Objective of the study

The objective of the present study is to measure and compare the efficiency and productivity of Indian public and private non-life insurance firms during the period 2008-09 to 2012-13 using Data Envelopment Analysis.

3 Review of Literature

Weiss [1] studied efficiency of 100 largest property liability insurers in the period 1980-1984. The output was incurred losses and inputs were labour expenses, intermediate expenses and capital. The study indicated that the excessive costs from non-optimal use of resources are estimated by this type of inefficiency.

A researcher measured the technical efficiency and productivity growth of 94 Italian insurance companies in 1985 using DEA and Malmquist productivity indices. The study used benefits plus changes in reserves as output in life insurance and incurred losses plus invested assets as output in non-life insurance. The inputs used, both in life and non-life insurance, were acquisition labour expense, administrative labour expense, fixed capital and equity capital. The research concluded that technical efficiency was in the range of 70%-78% during the study period. However, productivity declined significantly over the sample period, with a cumulative decline of about 25%.

Donni and Fecher [2] studied the technical efficiency in 15 OECD insurance markets over the period 1983. The outputs used for both life and non-life insurers were net premiums and input used is labour including intermediaries who sell insurance products without being employed by the insurance firms. The study explained that the growth in productivity observed in all countries is essentially attributable to improvements in technical progress.

Another researcher analysed the relative efficiency and productivity of 206 stock insurers and 211 mutual insurers in the period 1981-90 using input-oriented DEA and the Malmquist index approach. The present values of losses incurred were taken as insurance output and labour business services, debt capital and equity capital were taken as inputs. The results explained that stocks and mutual insurers are operating on separate production and cost frontiers, and thus, represent distinct technologies. However, consistent with the expense preference hypothesis, the stock insurers cost frontier dominates the mutual insurers cost frontier.

Diacon [3] studied the efficiency of UK specialist and composite insurers using DEA. This study used four inputs namely, total operating expenses, total capital, total technical reserve, and total borrowing from credits and three outputs namely, general insurance net earned premium, long-term insurance net earned premium and total investment income. The results indicate that UK general and composite insurance companies have the potential to be among the most efficient in Europe.

Diacon et al. [4] studied the efficiency of 450 European specialist and composite insurers doing long-term insurance business in fifteen European countries using VRS DEA to calculate the pure technical, scale and mix efficiencies of each insurer in the period 1996-1999. The study used total operating expenses, capital, technical reserves and borrowings as the inputs, premiums and investment income as the main outputs. The more efficient insurance companies in technical terms are likely to be either very large or very small (specialist) companies. It was found that insurers in the UK, Spain, Sweden and Denmark were likely to have the highest average levels of technical efficiency. Secondly, UK insurers

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seem to have particularly low levels of scale and mix efficiency when compared to their European counterparts. It was also found that average technical efficiency declined over the period of study.

Sinha [5] compared the technical efficiency of four public sector and six private sector general insurance companies using a non- radial DEA in period 2003-06. The outputs were net premium income and operating income; and inputs were operating expenses. It was found that that there was a decline in the mean technical efficiency in 2004-05 relative to 2003-04, but it increased again in 2005-06. Among the observed general insurance companies, Reliance and New India consistently have top level efficiencies for the period considered.

4 Data and Research Methodology

This study used the data from IRDA annual reports, annual reports and public disclosures of non-life insurance companies for the period from 2008-09 to 2012-13 using DEA. The data has been processed to remove the influence of the inflation. The scope of the study has been constrained to twelve private and four public non-life insurance firms based on their presence and operation for the whole period 2008-09 to 2012-13.

4.1 Concept of Efficiency and Data Envelopment Analysis

Efficiency deals with the firm's ability to produce a given set of outputs using inputs. Given the inputs and outputs, the efficiency of the DMU is converting the inputs to outputs can be defined as the ratio of sum of weighted outputs to sum of weighted inputs. The assessment of weights the most important and tricky as there is no unique set of weights. This issue of assigning weights is tackled in DEA by assigning a unique set of weights for each DMU. The weights for a DMU are determined; using mathematical programming, as those weights which will maximize its efficiency subject to the condition that the efficiencies of other DMUs (calculated using the same set of weights) is restricted to values between 0 and 1.

Mathematical Formulation of DEA

Data envelopment analysis (DEA) is a technique for measuring the relative efficiency of organizations given their multiple inputs and outputs. DEA is from the linear programming methodology to measure the relative performance of a Decision Making Units (DMUs, in this case an insurance company, relative to other DMUs in the given sample. The DEA methodology was originally developed by Charnes et al. [6] and was further extended by Banker et al. [7].

Let x and y represent inputs and outputs respectively and the subscripts i and j represent particular inputs and outputs respectively. Thus x_i represents the i^{th} input and y_j represent the j^{th} output of a decision making unit. Let the total number of inputs and outputs be represented by I >0 and J >0 respectively. Let there be N DMUs whose efficiencies have to be estimated and compared. Let us take one of the DMUs, say the m^{th} DMU and maximize its efficiency according the definition given above. The DMU for which the efficiency is maximized is normally termed as the reference DMU or the DMU under the assessment. Here the m^{th} DMU is the reference DMU. The mathematical formulation in matrix form is as follows:

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Model 1 : Max $E_m = V^T_m Y_m \ / \ U^T_m X_m$ subject to
$V^T_m Y - U^T_m X \leq 0$
$V^T_m, U^T_m > 0$ (1)
Where i= 1,2,…k…I; j= 1,2,…k…J; n=1,2,…k…N. Note that n includes m.
Where E_m is the efficiency of the m^{th} DMU, X is the matrix of inputs, Y is the matrix of outputs, U is the matrix of inputs and V is the matrix of outputs.

The above model when solved will give the values of weights U and V that will maximize the efficiency of the m^{th} DMU.If the efficiency is unity, then the firm is said to be efficient and will lie on the efficient frontier. Otherwise, the firm is said to be relatively inefficient. Note that the above program gives the efficiency of only one firm (the reference firm here). To get the efficiency scores of the other firms, more such mathematical programs have to be solved. Note that the above mathematical programs are fractional programs. It is generally difficult to solve fractional programs. They can be solved easily by converting them to linear programming formats. The simplest way to convert these fractional programs to linear programs is to normalize the denominator of the fractional programming objective function. Hence the weighted sum of the inputs is constrained to be unity in this fractional programming. As the objective functions the weighted sum of outputs that has to be maximized, this formulation is referred to the Output Maximization DEA program. Similarly, an analogous LP formulation is possible by minimizing the weighted sum of inputs, setting the weighted sum of outputs equal to unity and the formulation is the Input Minimization DEA Program.

Because of the nature of the formulations, the optimal objective function value of the input minimization DEA program for Firm A will be the reciprocal of the optimal objective function value(i.e., the value of efficiency) of the output maximization DEA program for Firm A. These were the original models introduced by Charnes et.al. [6]. Subsequently in 1979, the authors made a minor modification. In a traditional LP, the decision variables are non-negative. However, the authors chose to define the decision variables of the DEA programs (i.e., the weights) to be strictly positive. The models developed so far are called the CCR ([6]) models in the DEA framework. General output maximization CCR DEA model in matrix form can state as follows:

Model 2: Max $Z = V^T_m Y_m$ subject to $U^T_m X_m = 1$
$V^T_m Y - U^T_m X \leq 0$
$V^T_m, U^T_m > \varepsilon$ (2)
Where i= 1,2,…k…I; j= 1,2,…k…J; n=1,2,…k…N and X is the matrix of inputs and Y is the matrix of outputs. Similarly, a general input minimization CCR DEA model in matrix can be stated as follows:

Model 3: Min $Z` = U`^T_m X_m$ subject to $V`^T_m Y_m = 1$
$V`^T_m Y - U`^T_m X \leq 0$
$V`^T_m, U`^T_m > \varepsilon$ (3)

The Model 2 is linear and can be solved as usual LP techniques. However, in practice, is often solved as a dual formulation of the Model 2. The basic theory of LP states that every LP problem (usually called the primal problem) has another closely related linear program, called its dual. Thus, all the LP problems developed above have duals and the dual of a dual is primal. Hence the terms primal DEA program and dual program are relative. The DEA programs involving weights of inputs and outputs (U and V) are called Multiplier DEA

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programs and those involving weights (θ and λ) are called Envelopment DEA Programs. Output maximizing and input minimizing multiplier DEA programs have been discussed till now. A general envelopment DEA program corresponding to the output maximizing multiplier model in matrix form is as follows:

Model 4: Min θ_m such that

$\mathbf{Y}\lambda \geq \mathbf{Y}_m$

$\mathbf{X}\lambda \leq \theta\mathbf{X}_m$

$\lambda \geq 0$; θ_m free (4)

Similarly, the envelopment DEA program corresponding to the input minimizing multiplier model is given in matrix form:

Model 5: Max φ_m such that

$\mathbf{Y}\mu \geq \varphi_m\mathbf{Y}_m$

$\mathbf{X}\mu \leq \mathbf{X}_m$

$\mu \geq 0$; φ_m free (5)

The model version involving θ aims to produce the observed outputs with minimum inputs and hence this version is often referred to as an input oriented envelopment DEA program. The other version involving φ is referred to as an output oriented envelopment DEA program as it aims to maximize output subject to the given inputs. Note that the dual of the output maximizing multiplier program is the input oriented envelopment program. Similarly, the dual of the input minimizing multiplier program is the output oriented envelopment program.

Economies of Scale and Returns to Scale

Suppose that an organisation consumes inputs amounting to X1 and produces Y1 amounts of output. In automated production environment, it is possible to consume a certain amount of inputs and produce more than a proportional amount of output. That means by consuming a larger input X2 and can produce the output Y2, which is more than a proportional increase in output(Y2/Y1 > X2/X1). This concept is known Economy of Scale. In the above considered, the organisation is operating Increasing Returns to Scale as the firm's returns will increase by increasing firm's production. Increasing Returns to Scale (IRS) can be defined as a property of a production function such that changing all inputs by the same proportion changes the output by a greater extent the proportional value. But, beyond a limit, IRS doesn't hold as it might be difficult to produce that amount because of production issues such as storage and supply. In this case, it is said to be operating under Decreasing Returns to Scale (DRS). Combining the above two scenarios (IRS and DRS), it can be considered as VRS (Variables Returns to Scale). Note that the IRS changes to DRS at a particular level of production. Another variant of economies of scale is Constant Returns to scale (CRS).This property says that the firm is able to scale the inputs and outputs linearly without increasing or decreasing efficiency. The basic DEA models discussed so far assume that the operations follow CRS. This represented one of the most limitations of the applicability of DEA. Banker et al. [7] made a simple yet remarkable modification of introducing the convexity constraint:

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

to the CCR DEA models in order to handle VRS. Thus the DEA program for VRS is given as follows:

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Model 6: Min θ_m such that

$$\mathbf{Y}\lambda \geq \mathbf{Y}_m$$
$$\mathbf{X}\lambda \leq \theta\mathbf{X}_m$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda \geq 0 \; ; \; \theta_m \text{ free} \qquad (6)$$

In general, DEA Programs incorporating convexity constraint to take into account VRS are called BCC DEA models or VRS DEA Models whereas CCR DEA models are called CRS DEA models. Considering the fact that firms are assigned different efficiencies in case of CRS and VRS assumptions by using CCR Models and BCC Models respectively, two kinds of efficiencies can be considered- Technical and Scale efficiencies. The CCR model estimates the gross efficiency of a DMU. This efficiency comprises technical and scale efficiency. Technical efficiency describes the efficiency in converting inputs to outputs, while scale efficiency recognizes that economy of scale cannot be attained at all scales of production and that there is one most productive scale size, where the scale efficiency is maximum at 100%. The BCC model takes into consideration the variation of efficiency with respect to the scale of operation and hence measures pure technical efficiency. The CRS efficiency of a firm is always less than or equal to the VRS efficiency. Both are equal when the scale efficiency is unity or when the DMU is operating at the Most Productive Scale Size (MPSS). A firm is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input [8]. A firm is technically inefficient if it uses excessive inputs or produces too little outputs with the inputs availed [1].This study evaluates the technical and scale efficiency of Indian non-life insurance companies using output maximization DEA technique. It is meaningful to use output maximization model as the insurance industry in India in its early stage and has a large prospective potential to be targeted.

4.2 Concept of Productivity and Malmquist Productivity Index

Productivity is the measure of how well resources are brought together in a firm for accomplishing a set of results [9]. Miller and Schmidt [10] defines that productivity is a concept that concerns how well firm uses the resources in achieving the goals. Essentially, it is the ratio between the level output and the level of the input required to achieve that output. The study uses the Malmquist index by solving a series of linear programming problems to construct the distance functions.

The productivity change of any activity may be defined by two components: an efficiency change or a technological change. Efficiency change (EC) is calculated as the ratio between efficiency scores of the periods t+1 and t. Technological change (TC) is a measure of the shift in the frontier over the two periods [2]. Malmquist Index of productivity (TFPC) is the product of two factors EC and TC.

The value of index greater than *one* indicates the firm is more dynamic in embracing of new technology and shows a productivity growth between t and t+1 with relative to time t. A value of less than *one* represents a regress in productivity whereas equal to *one* indicates stagnation.

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Malmquist Productivity index makes use of distance functions to measure productivity change. Malmquist productivity index was introduced by Sten Malmquist [11] and further modified by Caves et.al. [12].

The distance function can be presented as an input distance function or an output distance function. In the present work, Malmquist productivity index will be defined using the output distance function. An output distance function using the given input vector describes a maximal proportional increase of the output vector. An input distance function describes the production technology by looking at a minimal proportional decrease of the input vector, given an output vector.

The production technology is defined as the set of all feasible input-output combinations. The production technology T in period t is

$T^t = (x^t, y^t)$ where t = 1… T

where x^t is a k-dimensional vector of non-negative inputs $x^t = (x^t_1 \ldots x^t_k) \in \Re^k_+$, y^t is an m-dimensional vector of nonnegative outputs $= (y^t_1, \ldots, y^t_m) \in \Re^m_+$ and T^t is the production possibility set for all feasible input-output combinations in period t.

The output distance function $D_0^t (X^t, Y^t)$ is measured as the distance of a vector of inputs and outputs in period t with respect to the technical frontier in period t:

$$D_0^t (X^t, Y^t) = \text{Inf} [\theta > 0: (X^t, Y^t/\theta) \epsilon T] , t = 1,\ldots,T$$

Where subscript *o* refers to output orientation.

The output distance function measures the maximum proportional change in output required to put (X, Y) on the efficiency frontier. If the evaluated production unit is efficient, $D_0(X, Y) = 1$ otherwise, $D_0(X, Y) < 1$. Let D_0^t(CRS) and D_0^t(VRS) denote the output distance function computed with period t technology and with CRS and VRS specification respectively. The distance function can be determined using the DEA methodology. Malmquist productivity index relies on firstly constructing an efficiency frontier over the whole sample realized by DEA and then computing the distance of individual observations from the frontier. In practice, this DEA based Malmquist productivity index has proven to be a good tool for measuring the productivity change of DMUs over time, and has been successfully applied in many fields.

The Malmquist index is a summary measure of the change in TFP of a given unit over time. Each unit is identified by its inputs-outputs (x, y) with the superscript indicating whether it is observed at time t and t+1. Following the Malmquist (output- oriented) TFP change index between period t (the base technology period) and period t+1 (the reference technology period) is given by

$$M_0^t(X_{t+1}, Y_{t+1}, X_t, Y_t) = D_0^t (X_{t+1}, Y_{t+1}) / D_0^t(X_t, Y_t)$$

Alternatively, the output based Malmquist productivity index with reference to period t+1 technology as $M_0^{t+1}(X_{t+1}, Y_{t+1}, X_t, Y_t) = D_0^{t+1} (X_{t+1}, Y_{t+1}) / D_0^t(X_t, Y_t)$

The output based Malmquist productivity change index can also be explained as follows

$$M_0(X_{t+1}, Y_{t+1}, X_t, Y_t) = \{[D_0^t (X_{t+1}, Y_{t+1}) / D_0^t(X_t, Y_t)][D_0^{t+1} (X_{t+1}, Y_{t+1}) / D_0^t(X_t, Y_t)]\}^{(1/2)}$$

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This is the geometric mean of output based Malmquist productivity indices with reference to period t and period t+1 technology. A value of less than 1 in the index indicates a regress (decline) in productivity, equal to 1 indicates stagnation and greater than 1 indicates a productivity growth between period t and t+1 from the perspective of period t.

$$[D_0^{t+1}(X_{t+1}, Y_{t+1}) / D_0^{t+1}(X_t,Y_t)] \{[D_0^{t}(X_{t+1}, Y_{t+1}) / D_0^{t+1}(X_{t+1},Y_{t+1})] [D_0^{t}(X_{t+1}, Y_{t+1}) / D_0^{t+1}(X_t,Y_t)]\}^{(1/2)}$$

Where $[D_0^{t+1}(X_{t+1}, Y_{t+1}) /D_0^{t+1}(X_t,Y_t)]$ is the change in relative technical efficiency between periods t and t+1
and $\{[D_0^{t}(X_{t+1}, Y_{t+1}) /D_0^{t+1}(X_{t+1},Y_{t+1})][D_0^{t}(X_{t+1}, Y_{t+1}) /D_0^{t+1}(X_t,Y_t)]\}^{(1/2)}$

captures the shift in technology (technological change) between the two time periods evaluated at (X_t, Y_t) and (X_{t+1}, Y_{t+1}). Hence TFP Change = TEC X TC.

Total Factor Productivity Change = Technical Efficiency Change x Technological Change.

Technical efficiency change measures the change in efficiency between current time period (t) and the next time period (t+1), while the technological change (innovation) captures the shift in frontier technology.

5 Analysis of Findings

The study explores the comparative efficiency and productivity of the Indian public and private non-life insurance companies in period 2008-2013 using DEA technique.

5.1 Efficiency Analysis of Indian Non-life Insurers

The study measures and compares the technical and scale efficiency of the Indian public and private sector non- life insurers in the period 2008-2013 using DEA. When it comes to the selection of inputs, there is a common agreement that labour (managerial, administrative and sales) and capitals are the main inputs used in the production of insurance. This study used Commission plus management expenses and capital as inputs, whereas net premium and investment income are taken as outputs.

Table 1 Technical Efficiency (CRS) of Non-life Insurers

Firm	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Bajaj Allianz	1.000	1.000	0.987	1.000	0.823	*0.962*
Bharti AXA	0.099	0.314	0.373	0.482	0.324	*0.318*
Cholamandalam	0.982	0.786	0.794	0.905	0.990	*0.891*
Future Generali	0.372	0.413	0.463	0.551	0.386	*0.437*
HDFC Ergo	0.596	0.712	0.839	0.962	0.594	*0.741*
ICICI Lombard	1.000	1.000	1.000	1.000	0.725	*0.945*
IFFICO Tokio	1.000	1.000	1.000	1.000	0.896	*0.979*
Reliance General	0.780	0.691	0.611	0.707	0.385	*0.635*
Royal Sundaram	1.000	1.000	1.000	1.000	0.925	*0.985*

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Firm	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
ShriRam General	0.874	1.000	1.000	1.000	1.000	*0.975*
Tata AIG	0.620	0.782	0.793	0.858	0.773	*0.765*
Universal Sompo	0.170	0.308	0.377	0.420	0.310	*0.317*
Mean	*0.708*	*0.751*	*0.770*	*0.824*	*0.678*	*0.746*
National	0.950	0.899	0.968	1.000	1.000	*0.963*
New India	0.875	0.759	0.886	0.642	0.393	*0.711*
Oriental	0.796	0.815	0.810	0.726	0.810	*0.791*
United India	0.802	0.886	0.937	0.745	0.532	*0.780*
Mean	*0.856*	*0.840*	*0.900*	*0.778*	*0.684*	*0.812*

Source: computed based on the IRDA Annual reports & firms annual reports: 2008-09 to 2012-13

From the Table-1 the technical efficiency (CRS) of each insurer has been analysed, and a comparative analyses has been done between public and private insurance firms for the period 2008-09 to 2012-13.Among the private non-life insurers, Bajaj Allianz, ICICI Lombard, IFFICO Tokio, Royal Sundaram and ShriRam General were observed as top level private non-life insurers having an average efficiency of 97.2%, 94.5%, 97.9%, 98.5% and 97.5% respectively. The second level private insurers were found to be Cholamandalam, Tata AIG, HDFC Ergo and Reliance with 89.1%, 76.5%, 74.1% and 63.5% efficiency respectively. Future Generali was with 43.7% efficiency level and Bharti AXA reported the least efficiency of 31.8% followed by Universal Sompo with 31.7% efficiency.

Bajaj Allianz, ICICI Lombard, IFFICO Tokio, Royal Sundaram and ShriRam General have shown 100 % percent efficiency during period 2008-09 to 2012-13 except one or two years with more than 95% efficiency

Coming to public non-life insurers, National was with 96.3% efficiency in the top level followed by Oriental, United India and New India with 79.1%, 78% and 71.1% respectively.

Except Cholamandalam in private, National and Oriental in public, all the other companies have shown less efficiency in 2012-13 compared to previous periods.

The numbers from the table, average technical efficiency under CRS of the public insurers is 81.2% whereas that of private insurers is 74.6%. Further, results uncover that the public non-life insurers are technically under CRS more efficient than the private non-life insurers. Although the mean efficiency level of private non-life insurers has shown an increasing trend from 70.8% to 82.4% during the period 2008-09 to 2011-12, but. 67.8% in 2012-13 whereas public non- life insurers have shown decreasing mean efficiency level except the year 2010-11. So, private insurers are working towards to achieve the higher efficiency levels.

Table 2 Technical Efficiency (VRS) of Non-life Insurers

Firm	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Bajaj Allianz	1.000	1.000	1.000	1.000	1.000	1.000
Bharti AXA	0.125	0.321	0.373	0.500	0.435	0.351
Cholamandalam	1.000	0.786	0.828	0.907	1.000	0.904
Future Generali	0.398	0.460	0.466	0.575	0.449	0.470
HDFC Ergo	0.623	0.915	0.843	0.986	0.708	0.815
ICICI Lombard	1.000	1.000	1.000	1.000	1.000	1.000
IFFICO Tokio	1.000	1.000	1.000	1.000	0.897	0.979

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Firm	2008-09	2009-10	2010-11	2011-12	2012-13	Mean
Reliance General	0.817	0.843	0.624	0.747	0.608	0.728
Royal Sundaram	1.000	1.000	1.000	1.000	0.933	0.987
ShriRam General	1.000	1.000	1.000	1.000	1.000	1.000
Tata AIG	0.642	0.784	0.797	0.893	0.776	0.778
Universal Sompo	0.200	0.351	0.378	0.465	1.000	0.479
Mean	*0.734*	*0.788*	*0.776*	*0.839*	*0.817*	*0.791*
National	1.000	1.000	1.000	1.000	1.000	1.000
New India	1.000	1.000	1.000	1.000	1.000	1.000
Oriental	0.971	1.000	0.999	0.951	0.895	0.963
United India	1.000	1.000	1.000	1.000	0.917	0.983
Mean	*0.993*	*1.000*	*1.000*	*0.988*	*0.953*	*0.987*

Source: computed based on the IRDA Annual reports & firms annual reports: 2008-09 to 2012-13

From the Table-2 the technical efficiency (VRS) of each insurer has been analysed, and a comparative analyses has been done between public and private insurance firms for the period 2008-09 to 2012-13.

Among the private non-life insurers, Bajaj Allianz, ICICI Lombard, ShriRam General, Royal- Sundaram and IFFICO Tokio were observed as top level private non-life insurers having an average efficiency of 100%, 100%, 100%, 98.7% and 97.9% respectively. The second level private insurers were found to be Cholamandalam, HDFC Ergo, Tata AIG and Reliance with 90.4%, 81.5%, 77.8% and 72.8% efficiency respectively. Universal Sompo and Future Generali were with 47.9% and 47.0% efficiency level respectively. Bharti AXA reported the least efficiency of 35.1%.Bajaj Allianz, ICICI Lombard, IFFICO Tokio, Royal Sundaram and ShriRam General have shown 100 % efficiency during period 2008-09 to 2012-13 except one or two years with more than 90% efficiency.

Among the public non-life insurers, National, New India and United India (except in 2012-13) were with 100% efficiency in the top level followed by Oriental with 96.3% efficiency score. Except the firms with efficiency 100% in all the years, other firms have shown less efficiency in 2008-09 & 2012-13 compared to other periods

The numbers from the table, average technical efficiency under VRS of the public insurers is 98.7% whereas that of private insurers is 79.1%.The difference in the scores can be reduced by the private non-life insurers by working towards achieving higher efficiency levels.

Table 3 Scale efficiency of Non-life Insurers

Firm	2008-09	rts	2009-10	rts	2010-11	rts	2011-12	rts	2012-13	rts	Mean
Bajaj Allianz	1.000	crs	1.000	crs	0.987	drs	1.000	crs	0.823	drs	*0.962*
Bharti AXA	0.795	irs	0.979	drs	0.998	irs	0.964	irs	0.745	drs	*0.896*
Cholamandalam	0.982	irs	1.000	crs	0.958	drs	0.998	irs	0.990	irs	*0.986*
Future Generali	0.935	irs	0.897	drs	0.994	irs	0.957	irs	0.860	drs	*0.929*
HDFC Ergo	0.957	irs	0.778	drs	0.995	irs	0.975	irs	0.839	drs	*0.909*
ICICI Lombard	1.000	crs	1.000	crs	1.000	crs	1.000	crs	0.725	drs	*0.945*
IFFICO Tokio	1.000	crs	1.000	crs	1.000	crs	1.000	crs	0.999	drs	*1.000*
Reliance General	0.955	drs	0.819	drs	0.979	irs	0.947	drs	0.634	drs	*0.867*

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Firm	2008-09	rts	2009-10	rts	2010-11	rts	2011-12	rts	2012-13	rts	Mean
Royal Sundaram	1.000	crs	1.000	crs	1.000	crs	1.000	crs	0.992	irs	*0.998*
ShriRam General	0.874	irs	1.000	crs	1.000	crs	1.000	crs	1.000	crs	*0.975*
Tata AIG	0.966	irs	0.997	drs	0.995	irs	0.961	drs	0.996	irs	*0.983*
Universal Sompo	0.849	irs	0.878	drs	0.998	irs	0.904	irs	0.310	irs	*0.788*
Mean	*0.943*		*0.946*		*0.992*		*0.976*		*0.826*		*0.936*
National	0.950	drs	0.899	drs	0.968	drs	1.000	crs	1.000	crs	*0.963*
New India	0.875	drs	0.759	drs	0.886	drs	0.642	drs	0.393	drs	*0.711*
Oriental	0.819	drs	0.815	drs	0.810	drs	0.763	drs	0.904	drs	*0.822*
United India	0.802	drs	0.886	drs	0.937	drs	0.745	drs	0.580	drs	*0.790*
Mean	*0.862*		*0.840*		*0.900*		*0.788*		*0.719*		*0.822*

Source: computed based on the IRDA Annual reports & firms annual reports: 2008-09 to 2012-13.
crs :contant return to scale, (drs): decreasing return to scale and irs: increasing return to scale

Table-3 explains the scale efficiency and return to scale (rts) of the four public sector non-life insurers and twelve private sector non-life insurance firms under study.

The average scale efficiency of the private sector is higher than that of the public sector. The average scale efficiency of private sector is 93.6% whereas in the case of public sector it is 82.2%.

Among private non-life insurers, Bajaj Allianz, ICICI Lombard, IFFICO Tokio, Royal sundaram and ShriRam General (except 2008-09) have shown 100% full scale efficiency (except in the year 2012-13) with mean efficiency of 96.2%,94.5%,99.8% and 97.5% respectively. But the top private non-life insurers were Royal Sundaram, Tata AIG, Cholamandalam, ShriRam General, and Bajaj Allianz with higher mean level scale efficiency of 99.8%, 98.3%, 98.6%, 97.5% and 96.2% respectively.

In terms of their mean scale efficiency, the next level firms were Future Generali, HDFC Ergo, and Reliance with 92.9%, 90.9% and 86.7% respectively. And the least scale efficient among the private insurers is Universal Sompo with mean scale efficiency of 78.8%.

Among the public non-life insurers, National and Oriental insurance firms have shown high mean scale efficiency of 96.3% and 82.2% respectively, followed by United India and New India with respective mean scale efficiency score of 79% and 71.1% respectively. From the Table 3, the mean scale efficiency of public non-life insurers has shown decreasing trend except the year 2010-11 whereas in case of private non-life insurers it has shown increasing trend (except the year 2012-13).That means, that the efficiency of private non-life insurers improved with the passage of time.

All the public non-life insurers mostly decreasing return to scale, except National Insurance in the years 2011-12 and 2012-13.Among the private non-life insurers, all the firms mostly have shown either increasing reruns to scale or constant returns to scale most of the times except in the year 2012-13.Clearly, it can be iterated that to improve scale efficiency and to attain constant return to scale in the long run, the private non-life insurers have to enhance their business to get the benefit of large scale economy.

Overall, the technical efficiency of public sector non-life insurers both under CRS and VRS is higher than that of the private sector, but the scale efficiency of the public sector non-life insurers is smaller than that of the private sector non-life insurers during the period from 2008-09 to 2012-13.The analysis also revealed that most of the public sector non-life insurers have shown decreasing rerun to scale and private sector non-life insurers have shown

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increasing return to scale. Further, to improve the efficiency, private sector non-life insurers have to expand their business to get the advantage from the large scale economy.

5.2 Productivity Analysis of Indian Non-Life Insurers

Table-4 shows the technical efficiency change of the public and private sector non-life insurers over the period under study.

Table 4 Malmquist Growth in Technical Efficiency Index of Non-life insurers

Firm	2009-10	2010-11	2011-12	2012-13	Mean
Bajaj Allianz	8.452	1.300	1.146	1.156	1.953
Bharti AXA	1.000	0.706	0.706	0.925	0.824
Cholamandalam	5.581	1.078	0.981	1.080	1.589
Future Generali	1.428	0.793	0.780	1.232	1.021
HDFC Ergo	2.446	1.157	0.890	1.087	1.286
ICICI Lombard	8.874	1.162	0.987	1.359	1.928
IFFICO Tokio	7.890	1.205	1.176	1.052	1.852
Reliance General	6.973	1.884	1.304	1.056	2.062
Royal Sundaram	7.415	1.194	1.030	1.345	1.871
ShriRam General	1.449	0.764	0.921	0.642	0.899
Tata AIG	8.417	1.009	0.894	1.276	1.764
Universal Sompo	1.000	1.000	1.000	1.000	1.000
Mean	*3.731*	*1.068*	*0.972*	*1.082*	*1.431*
National	6.091	1.124	1.449	1.719	2.032
New India	7.564	1.271	1.096	1.319	1.931
Oriental	6.739	1.309	1.177	1.894	2.106
United	6.915	1.247	1.009	1.711	1.964
Mean	*6.807*	*1.236*	*1.172*	*1.661*	*2.011*

Source: Computed based on the IRDA Annual reports & firms annual reports: 2008-09 to 2012-13

All the non-life insurers have shown a decreasing trend in their technical efficiency change till 2011-12 and improvement in 2012-13.It is found that the there is considerable drop in the technical efficiency change of the public non-life insurers in the year 2010-11 from the previous year 2009-10, again a drop of 6.4% in the year 2011-12 from the year 2010-11, later observed an increase of 48.9% in the year 2012-13.The geometric mean of technical efficiency change of the public non-life insurers is 2.011 which tells that there is gain of 101% in their efficiency change. The geometric mean of efficiency change of National, Oriental is more than 100% and that of United India & New India is 96.4% and 93.1% respectively.

The geometric mean of efficiency change of the private non-life insurers is 1.431, indicating 43.1% improvement in efficiency level. Among the private non- life insurers, Reliance General has shown a geometric mean efficiency change of 2.062, indicating 106% improvement in technical efficiency level during the study period, followed by Bajaj Allianz with 95.3%, ICICI Lombard with 92.8%, Royal Sundaram with 87.1%, IfficoTokio with 85.2%, Tata AIG with 76.4%, Cholamandalam with 58.9% and HDFC Ergo with 28.6% growth in technical efficiency change. Further, Bharti AXA and ShriRam have shown mean technical efficiency change of 0.824 and 0.899 respectively, explaining 18% and10% decline in efficiency level during the period under study. Universal Sompo has shown no change in its efficiency level over the period under study. It has been observed that the technical efficiency

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progress of the public sector non-life insurers is higher than that of the private sector non-life insurance companies over the period under study.

Table 5 Malmquist Growth in Technology Index of Non-life insurers

Firm	2009-10	2010-11	2011-12	2012-13	Mean
Bajaj Allianz	0.248	1.079	1.086	0.977	0.730
Bharti AXA	0.302	0.729	1.169	0.702	0.652
Cholamandalam	0.287	1.079	1.086	0.804	0.721
Future Generali	0.500	0.831	1.123	0.769	0.774
HDFCErgo	0.359	0.907	1.086	0.888	0.749
ICICI Lombard	0.209	1.079	1.086	0.862	0.678
IFFICO Tokio	0.213	1.079	1.086	0.977	0.703
Reliance General	0.249	1.079	1.086	0.977	0.731
Royal Sundaram	0.199	1.017	1.086	0.869	0.661
ShriRam General	0.318	0.838	1.031	0.885	0.702
Tata AIG	0.172	0.920	0.983	0.808	0.595
Universal Sompo	0.243	0.732	0.976	0.663	0.582
Mean	*0.264*	*0.938*	*1.072*	*0.842*	0.687
National	0.213	0.847	0.938	0.484	0.535
New India	0.151	0.816	0.871	0.737	0.530
Oriental	0.165	0.788	0.841	0.523	0.489
United	0.144	0.763	0.815	0.628	0.487
Mean	*0.166*	*0.803*	*0.865*	*0.593*	0.512

Source: Computed based on the IRDA Annual reports & firms annual reports: 2008-09 to 2012-13

Table-5 shows the technological change of the public and private sector non-life insurance firms in the period under study. The table reveals that all the non-life insurers made technological regress during the study period. The geometric mean of technological change of private sector non-life insurers is 68.7%, indicating 31.3% regress in technological change, whereas in case of public non-life insurers it is 51.2%, indicating 48.8% regress in technological change. Overall the numbers indicate that the public sector non-life insurers have shown more regress in technological change than the private non-life insurers.

Hence, this decline in technological change tells that the insurers need more inputs to produce their outputs at the end of the period under study that at the beginning. Also, it appears that most of the private non-life insurers implemented new methods to increase their inputs, but resulted in excessive use of input resources. Hence, the private non-life insurers have to enhance their technology with care in this competitive atmosphere. This also holds good for public sector non-life insurers in enhancing their technology in the period under study.

Table 6 Malmquist Total Factor Productivity Index of Non-life insurers

Firm	2009-10	2010-11	2011-12	2012-13	Mean
Bajaj Allianz	2.096	1.403	1.245	1.129	1.426
Bharti AXA	0.302	0.515	0.825	0.649	0.537
Cholamandalam	1.602	1.163	1.065	0.868	1.146
Future Generali	0.714	0.659	0.876	0.947	0.790
HDFC Ergo	0.878	1.049	0.967	0.965	0.963
ICICI Lombard	1.855	1.254	1.072	1.171	1.307
IFFICO Tokio	1.681	1.300	1.277	1.028	1.301
Reliance General	1.736	2.033	1.416	1.032	1.507
Royal Sundaram	1.476	1.214	1.119	1.169	1.237
ShriRam General	0.461	0.640	0.950	0.568	0.632

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Firm	2009-10	2010-11	2011-12	2012-13	Mean
Tata AIG	1.448	0.928	0.879	1.031	1.050
Universal Sompo	0.243	0.732	0.976	0.663	0.582
Mean	*0.984*	*1.001*	*1.042*	*0.911*	0.983
National	1.297	0.952	1.359	0.832	1.087
New India	1.142	1.037	0.955	0.972	1.024
Oriental	1.112	1.031	0.990	0.991	1.030
United	0.996	0.951	0.822	1.075	0.957
Mean	*1.132*	*0.992*	*1.014*	*0.967*	1.024

Source: Computed based on the IRDA Annual reports & firms annual reports: 2008-09 to 2012-13

Table-6 shows the Malmquist productivity indices of the public and private non-life insurance firms. It is clear from the table that all non-life insurers have shown decline in their overall productivity from 2009-10 to 2012-13, even though there is increase in 2010-11 and 2011-12. Among the public sector non-life insurers, the geometric mean of the productivity change of National Insurance is 1.087, which explains that the company has shown progress of 8.7% in its productivity during the study period and other three public non-life insurers New India, Oriental and United India have shown progress of 2.4%, 3.0% and regress of 4.3% in their productivity respectively during the period of study. Among the private non-life insurers, the geometric mean of the productivity change of Reliance General is 1.507, which tells that Reliance has shown progress of 50.7% in its productivity during the study period. Other private non- life insurers Bajaj Allianz, ICICI Lombard, IFFICO Tokio, Royal Sundaram, Cholamandalam and TataAIG were with 32.8%,30.7%, 30.1%, 23.7%, 14.6% and 5% progress in their productivity during the study period. But the remaining private non- life insurers HDFC Ergo, Future Generali, ShriRam General,Universal Sompo and Bharti AXA with regress of 2.2%,3.7%,21.0%, 36.8%, 41.8% and 46.3% in their productivity change over the period under study. Overall, by the end of the period under study, public non-life insurers have shown progress (2.4%) in productivity change whereas private non-life insurers have shown regress (1.7%).

Also, it has been observed that the 43.1% progress in Technical efficiency change of private non-life insurers is being countered by 31% regress in technology change, which resulted in 1.7% decline in overall total factor productivity of the private sector non-life insurers over the period under study. The public non-life insurers have shown 101% improvement in technical efficiency change and 51.2% decline in technology change, which led to 2.4% increase in their total factor productivity.

6 Concluding Remarks

The public sector non-life insurers were technically more efficient under CRS & VRS than the private non-life insurers, but private insurers were more scale efficient than the public insurers. Overall, the private non-life insurers Bajaj Allianz, ICICI Lombard, IFFICO Tokio, Royal Sundaram and ShriRam General have shown higher levels of efficiency followed by Cholamandalam, Tata AIG, HDFC Ergo, Reliance, Future Generali and Universal Sompo at the next level. Bharti AXA has shown least efficiency among the private insurers. Among the public non-life insurers, National and Oriental have shown higher efficiency levels followed by United India and New India at the next level. Also, most of the public sector non-life insurers have shown decreasing return to scale and private sector non-life insurers has shown increasing return to scale.

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The technical efficiency progress of the public sector non-life insurers is higher than that of the private sector non-life insurance companies over the period under study. Public sector non-life insurers have shown more regress in technological change than the private non-life insurers. Public non-life insurers have shown less regress in productivity change than the private non-life insurers. All non-life insurers have shown decline in their overall productivity in the study period.

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