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A Mathematical Modelling Approach to Efficiency Ranking Of Indian Non-Life Insurance Firms Using Super-Efficiency and Cross-Efficiency DEA Models

R.Venkateswarlu[1], G. S. S. Bhishma Rao[2]
[1,2,] *(GITAM School of International Business, GITAM University, Visakhapatnam ,India)*

Abstract: *This paper uses the DEA models to rank the efficiency of Indian non-life insurance firms over the period 2008-2013 with Expenses, Capital, Premium and Investment income variables in the modelling. These basic DEA models identify adequately the inefficient firms, but are weak in discriminating among those found to be efficient. To improve the discrimination, we used the Cross-Efficiency and the Super-Efficiency DEA models.*
Keywords*: Efficiency, Data Envelopment Analysis(DEA),Non-life Insurance Firms*

I. Introduction

Insurance is a socio economic device of risk management in which the insured transfers the cost of potential loss to another entity known as insurer against a payment known as the premium. Non-life insurance comprises of insuring property (homes, auto, etc.,) against fire and burglary, floods, storms, earthquakes and so on. It covers property insurance, health insurance, liability insurance which guards legal liabilities etc. This work aims to measure and rank the relative efficiency of Indian non-life insurance using super-efficiency and cross-efficiency DEA models. In other words, the main objective is to measure and rank the relative efficiency of the Indian non-life insurance firms using super-efficiency and cross-efficiency scores. This study can also be used as benchmark the efficiency of insurance companies based on the efficiency scores.

II. An Overview Of Non-Life Insurance Companies In India

Insurance in India used to be strictly regulated and monopolised by state-run insurers. After the move towards economic change in the early 1990s and the Malhotra committee in 1993 made reforms in the insurance sector and finally resulted in the formation of the Insurance Regulatory and Development Authority (IRDA) Act of 1999 which is brining the changes in insurance sector. The major duty of IRDA is 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 parties are allowed to start insurance companies in India. Insurance market of India opened to foreign companies with a cap on the shareholding at 26% in the joint venture with Indian companies. The following table lists the non life insurers in India:

NON-LIFE INSURERS*			
	Public Sector		**Private Sector**
1	National Insurance Co. Ltd.	1	Bajaj Allianz General Insurance Co. Ltd.
2	The New India Assurance Co. Ltd.	2	Bharti AXA General Insurance Co. Ltd.
3	Oriental Insurance Co. Ltd.	3	Cholamandalam MS General Insurance Co. Ltd
4	United India Insurance Co. Ltd.	4	Future Generali India Insurance Co. Ltd.
		5	HDFC ERGO General Insurance Co. Ltd.
	Specialised Insurers	6	ICICI Lombard General Insurance Co. Ltd.
5	Agriculture Insurance Co. Ltd.	7	IFFCO Tokio General Insurance Co. Ltd.
6	Export Credit Guarantee Corporation Ltd.	8	L & T General Insurance Co. Ltd
		9	Liberty Videocon General Insurance Co. Ltd.
		10	Magma HDI General Insurance Co. Ltd.
		11	Raheja QBE General Insurance Co. Ltd.
		12	Reliance General Insurance Co. Ltd.
		13	Royal Sundaram Alliance Insurance Co. Ltd.
		14	SBI General Insurance Co. Ltd.
		15	Shriram General Insurance Co. Ltd.
		16	TATA AIG General Insurance Co. Ltd.
		17	Universal Sompo General Insurance Co. Ltd.
			Standalone Health Insurers
		18	Apollo Munich Health Insurance Co. Ltd.
		19	Max Bupa Health Insurance Co. Ltd.
		20	Religare Health Insurance Co. Ltd.
		21	Star Health and Allied Insurance Co. Ltd.
RE – INSURER*			

III. Literature Review

In India as well as in Asian countries, studies about efficiency in the insurance industry have emerged very recently using non parametric approaches. Research about efficiency in insurance employs frontier models. One of non-parametric methods is the data envelopment analysis (DEA), which is a Linear Programming from the branch of Operations Research.DEA allows the use of multiple inputs and outputs and does not impose any functional form on the data, neither does it make distributional assumptions for the inefficiency term. The DEA method is widely used in measuring productive efficiency of firms by the consideration of multi-inputs and outputs. DEA methodology uses linear programming technique to convert inputs into outputs. (Charnes et.al. 1981).

The basic DEA models do well at identifying the inefficient units, but are weak in discriminating among the efficient units (Seiford and Zhu, 1999). To overcome this problem, we use the Cross-Efficiency DEA model (Sexton, Silkman and Hogan, 1986; and Doyle and Green, 1994) and the Super-Efficiency DEA model (Andersen and Petersen, 1993).

Joy and Partha (2012) studied the performance and efficiency in terms of Total factor Productivity (TFP) growth of 13 Indian life insurance companies (12 private sector and 1 public sector) in respect of Catch-up efficiency and Frontier-shift efficiency for the FYs ranging from 2003-04 to 2009-10 using Data Envelopment Analysis (DEA).For this purpose, Net Premium Income and Number of products launched during the year has been taken as the output indicators and Operating expenses along with Commission expenses has been taken as the inputs.

Garg and Deepti(2008) explored the technical and scale efficiency of 12 general insurance companies in India from the financial year 2002-03 to 2005-06 using Data Envelopment Analysis (DEA). Among the public insurers, New India is the only company which turned out to be technically efficient on both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) for all the years under reference.

Tone and Sahoo(2005) applied a new model variant of data envelopment analysis model to examine the performance of Life Insurance Corporation (LIC) of India. The results show a significant heterogeneity in the cost efficiency scores over the course of 19 years. A decline in performance after 1994–1995 can be taken as evidence of increasing allocative inefficiencies arising from the huge initial fixed cost undertaken by LIC in modernizing its operations. A significant increase in cost efficiency in 2000–2001 is, however, cause for optimism that LIC may now be realizing a benefit from such modernization

Kaur and Navjeet(2013) studied the efficiency of insurers in terms of their investment behaviour. Two models have been used in the data envelopment analysis (DEA) in order to measure their efficiency. For the first model, one input as investment under management and two indicators of output as net returns on investments to the shareholders and net returns on investments to the policyholders have been used. Among the public sector insurers, New India has been the most efficient of all the insurers. For the second model, two inputs, i.e. capital (including reserves and surpluses) and net premium income, and one output as investment under management have been used.. The United India Insurance Company has been the most efficient of all the insurers according to the second model.

Most of these studies use previous research and techniques, with little improvement in methodology and application.

Andersen and Petersen (1993) proposed the use of the CRS super-efficiency model for ranking efficient DMUs in DEA.Cross efficiency helps remove one problem with DEA, where most of the weight in a ratio can be placed on a single variable, with the rest being given near zero weights. Several methods of restricting weights have been tried but are arbitrary Allen.et.al [1994]. Doyle and Green [1994] says that the cross efficiency allows analysis based on peer appraisal with weights which are internally derived rather than externally imposed

We have not found studies on the Indian insurance market applying super-efficiency and cross-efficiency in efficiency ranking of the Indian non-life Insurance firms.
We consider that the use of modern methods like super efficiency and cross efficiency is a relevant avenue for further research on mathematical modelling of efficiency studies in Indian insurance markets.

IV. Methodology

This study used the data from IRDA annual reports, company annual reports and public disclosures of Indian non-life insurance companies for the period from 2008-09 to 2012-13.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 Indian non-life insurance firms based on their presence and operation for the whole period 2008-09 to 2012-13.

The objective of the present study is to apply super-efficiency and cross-efficiency DEA models to rank the efficiency of Indian non-life insurance firms during the period 2008-09 to 2012-13.

4.1. Super Efficiency Data Envelopment Analysis (SE-DEA)

Classical DEA models measure the relative efficiency of DMUs but do not allow ranking of the efficient DMUs. One suggested solution by Andersen and Petersen (1993) to this problem is to remove the condition that restricts efficiency to one. This modification to the basic DEA framework is explained as follows:

The DEA method is widely used in measuring productive efficiency of firms by the consideration of multi-inputs and outputs. DEA methodology uses linear programming technique to convert inputs into outputs. (Charnes et.al. 1981). The key attribute of this method is that it doesn't require any functional form between multi-inputs and outputs. Also, DEA defines a "frontier" in order to measure the relative performance of firms against the best firms. The efficiency score in DEA model ranges from 0 to 1. The score of 1 defines maximum efficiency, whereas a score of less than 1 defines inefficiency and showing the relative movement away from the efficient frontier. There are two ways of understanding efficiency: (1) to produce a greater quantity of outputs with the fixed inputs and (2) to use fewer levels of inputs with the fixed outputs. DEA analyses helps in finding the reason of inefficiency of the DMUs.

The variation in DEA depends on whether it is an input-oriented or output-oriented model and whether its situation presents a constant-return-to-scale (CRS) or variable-return-to-scale (VRS) requirement. The input-oriented DEA model minimizes quantity of input, producing the fixed outputs as the DMU in question. Whereas, the output-oriented DEA model maximizes quantity of output with fixed inputs as the DMU in question. The CRS model defines that output level is proportional to the level of the input for a given unit. Whereas, VRS model defines the level of output is proportionally higher or lower than an increase in inputs

According to Charnes, Cooper, & Rhodes (1981), the output-oriented CCR-DEA model measures the efficiency scores (Ej) for peer DMUs (j = 1 to p). The efficiency measurement depends on the selected outputs (Y_{ij}, i = 1 to n) and inputs (X_{kj}, k = 1 to m) expressed by the linear programming technique:

$$\text{Max } E_j = \sum_{i=1}^{n} v_{ij} \; Y_{ij} \tag{1}$$

$$\text{Subject to constraints: } \sum_{k=1}^{m} u_{kj} \; X_{kj} = 1 \tag{2}$$

$$\sum_{i=1}^{n} v_{is} \; Y_{is} \quad \leq \quad \sum_{k=1,}^{m} u_{ks} \; X_{ks} \tag{3}$$

$$\text{Where } v_{ij} \text{ , } u_{kj} \; \geq 0 \; \forall \, i, j, k \tag{4}$$

The observed outputs (Y_{ij}) and inputs (X_{kj}) are considered as the constants. Output weight (v_{ij}) added to maximize the efficiency of DMU j, whereas input weights (u_{kj}) conform the constraints of Eq(2). Finally, the technical efficiency of each DMU j is solved by adapting the linear programming technique, providing the score with an upper bound of one. This upper limit is forced by constrained set as Eq (3).

As explained earlier, classical DEA model determines which DMUs are efficient, but it does not give a way to rank the DMUs and the suggested solution to rank the DMUs is termed as " Super Efficiency " by Andersen and Petersen (1993) to this problem is to remove the condition that limits efficiency to 1. In order to get super efficiency scores, the constraint forcing the inputs to exceed the outputs (Eq. 3) must be relaxed for the DMU under consideration. This Super Efficiency technique allows to examine the degree to which DMU's go above the efficient frontier. This allows efficient DMU's to be ranked. Note that the efficiency values of inefficient units remain unchanged from their classical DEA efficiency values.

Andersen and Petersen (1993) proposed the use of the CRS super-efficiency model for ranking efficient DMUs in DEA.

$$\text{Max } E_j = \sum_{i=1}^{n} v_{ij} \; Y_{ij} \tag{5}$$

$$\text{Subject to constraints: } \sum_{k=1}^{m} u_{kj} \; X_{kj} = 1 \tag{6}$$

$$\sum_{i=1,s\neq j}^{n} v_{is} \; Y_{is} \quad \leq \quad \sum_{k=1,s\neq j}^{m} u_{ks} \; X_{ks} \tag{7}$$

$$\text{Where } v_{ij} \text{ , } u_{kj} \; \geq 0 \; \forall \, i, j, k \tag{8}$$

The linear programming technique is used to solve the above formulation for each DMU, allowing continuous technical efficiency score measurement with unrestricted bound. The difference of super-efficiency and classical data envelopment analysis (CCR-DEA) models is the exclusion of DMU j in the constraint set in Eq(7).As described earlier, when the DMU j is included in Eq(7), making the maximum score of efficiency can be restricted to one. Notably, the under evaluation DMU j is no longer in the second constraint ($s \neq j$). Thereby, the outputs are maximized without restriction and in turn the ranking of efficient DMUs will be arrived.

4.2 Cross Efficiency Data Envelopment Analysis (CE-DEA)

Cross-efficiency estimation has been suggested as an alternative method of efficiency evaluation and ranking in Data Envelopment Analysis (DEA) based on peer evaluation logic. Sexton et al. (1986) first introduced the idea of cross-efficiencies in DEA. The basic idea is to use DEA in a peer-evaluation instead of a self-evaluation which is calculated by the classic DEA models. A peer-evaluation means that the efficiency score of a DMU gets when evaluated with the optimal weights (input and output weights determined by the classic DEA models) of other DMUs. Thus, for each of the n DMUs there will be n-1 cross-efficiencies. Doyle and Green [1994] further re iterated that cross efficiency is a two stage efficiency estimation process. First the basic DEA model is executed and later cross efficiencies will be calculated by comparing every DMU with all other DMUs, applying the weights of the other DMUs, from the original DEA estimation, to the DMU under consideration to ascertain the effect of this has on the original DMU's efficiency rating.

Consider n DMUs each one consumes m inputs to produce s outputs. The inputs and outputs for all of the DMUs are strictly positive and the relative efficiency of each DMUo is measured by the following DEA model:

$$\text{Max } \mu_o = \sum_{r=1}^{s} u_{ro} Y_{ro} \quad (1)$$

$$\text{Subject to constraints: } \sum_{i=1}^{m} v_{io} X_{io} = 1 \quad (2)$$

$$\sum_{r=1}^{s} u_{is} Y_{rj} \leq \sum_{i=1,}^{m} v_{io} X_{ij} \quad j = 1 \text{ to } n \quad (3)$$

$$\text{Where } u_{ro}, v_{io} \geq 0 \ \forall \quad r = 1 \text{ to } s, \ i = 1 \text{ to } m \quad (4)$$

where Y_{rj}, r = 1,…,s and X_{rj} i = 1,…,m represent outputs and inputs for each DMU_j respectively. Whereas DMU_o is the DMU under efficiency evaluation as explained earlier. Efficiency score of DMU_j using the weights produced by evaluation model of DMUo is defined as follows:

$$E_{oj} = \frac{\sum_{r=1}^{s} u_{ro} y_{rj}}{\sum_{i=1}^{m} v_{io} x_{ij}} \quad j = 1 \text{ to } n$$

The average of all E_{oj} , d =1 to n is a new efficiency measure for DMU_j, j= 1 to n This efficiency is called the cross efficiency of DMU_j and is as follows:

$$\overline{E}_j = \frac{\sum_{o=1}^{n} E_{oj}}{n} \quad j = 1 \text{ to } n$$

Cross efficiency provides a measure of the efficiency that not only the best multiplier collection for DMU_o under evaluation, but also the best collections for all other DMUs.

An average cross efficiency score is arrived at from the matrix used to of cross efficiencies, see Table 1. It is expected that average cross efficiency scores is lower than the original scores, as a DMU cannot have a cross efficiency score higher than the original DEA score.

In Table 1 of Matrix of cross efficiencies, basic DEA efficiencies are in the leading diagonal, E21 is the cross efficiency of DMU2 using DMU1's weights.

Table1:Matrix of Cross Efficiencies

	DMU1	DMU2	.	.	.	DMU n
DMU1	E11	E12	.	.	.	E1n
DMU2	E21	E22	.	.	.	E2n
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
DMU n	En1		.	.	.	Enn
	$\overline{\mathbf{E1}}$	$\overline{\mathbf{E2}}$	**.**	**.**	**.**	$\overline{\mathbf{En}}$

A comparison score can be done by averaging down each column gives the DMUs average cross efficiency ($\overline{E}_i$) using its own inputs and outputs and other DMUs weights (average appraisal by peers). This analysis helps in ranking of DMUs, including those which are on the production frontier as the basic DEA cannot provide adequate discrimination among efficient decision making units (DMUs). Cross efficiency helps remove one problem with DEA, where most of the weight in a ratio can be placed on a single variable, with the rest being given near zero weights. Several methods of restricting weights have been tried but are arbitrary Allen.et.al [1994]. Doyle and Green [1994] says that the cross efficiency allows analysis based on peer appraisal with weights which are internally derived rather than externally imposed. The cross efficiency average scores are perceived as demonstrating a true peer assessment as each DMU is assessed as how it performs using all other DMUs weights, thereby giving DMUs all round efficiency. In other words, irrespective of combination of weights are used on a DMUs inputs and outputs, if a DMU has a high cross efficiency score on average it tells that they are actually using their inputs and outputs efficiently. This is a type of sensitivity analysis, as different sets of weights are used to each DMU, running the DEA model again each time. Clearly the true number of potential weight combinations is more than the usual, as stated previously that the intuitively appealing process of using the weights from within the analysis process rather than some arbitrary external use of weights is used

V. Empirical Analysis

5.1 Data, Inputs and Outputs

This study used the data from IRDA annual reports and public disclosures of Indian non-life insurance companies for the period from 2008-09 to 2012-13.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 Indian non-life insurance firms based on their presence and operation for the whole period 2008-09 to 2012-13. Also, the inputs used are commission plus management expenses and capital whereas the outputs used are net premium income and investment income. The orientation of the CCR-DEA model is output orientation as 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

5.2 Results - Efficiency Scores and Ranks

Using the basic CCR- DEA model the CRS technical efficiency scores are given as below

Table2: CCR-DEA(CRS) Efficiency Scores of Indian Non-Life Insurers

Firm/CCR_DEA SCore	2008-09	2009-10	2010-11	2011-12	2012-13
BajaiAllianz	**100.0**	**100.0**	98.7	**100.0**	82.3
BhartiAXA	9.9	31.4	37.3	48.2	32.4
CholaMS	98.2	78.6	79.4	90.5	99.0
FutureGenerali	37.2	41.3	46.3	55.1	38.6
HDFCErgo	59.6	71.2	83.9	96.2	59.4
ICICILombard	**100.0**	**100.0**	**100.0**	**100.0**	72.5
IFFICOTokio	**100.0**	**100.0**	**100.0**	**100.0**	89.6
RelianceGeneral	78.0	69.1	61.1	70.7	38.5
RoyalSundaram	**100.0**	**100.0**	**100.0**	**100.0**	92.5
ShriRamGeneral	87.4	**100.0**	**100.0**	**100.0**	**100.0**
TataAIG	62.0	78.2	79.3	85.8	77.3
UniversalSompo	17.0	30.8	37.7	42.0	31.0
National	95.0	89.9	96.8	**100.0**	**100.0**
New India	87.5	75.9	88.6	64.2	39.3
Oriental	79.6	81.5	81.0	72.6	81.0
United India	80.2	88.6	93.7	74.5	53.2

As discussed earlier, basic DEA models measure the relative efficiency of DMUs but do not allow ranking of the efficient DMUs. To distinguish between the efficient firms, whose CCR-DEA score is 1, we employed the SE-DEA and CE-DEA Models to measure and rank the efficiencies of the Insurance firms.

Table 3: Super Efficiency Scores of Indian Non- life Insurers

Firm/SE Score	2008-09	2009-10	2010-11	2011-12	2012-13
Bajaj Allianz	110.63	100.43	98.69	100.96	82.31
Bharti AXA	9.91	31.43	37.27	48.21	32.36
Chola MS	98.25	78.62	79.4	90.52	99.03
Future Generali	39.21	41.28	46.3	55.07	38.59
HDFC Ergo	59.64	71.15	83.89	96.18	59.41
ICICI Lombard	115.56	118.51	123.27	108.88	72.47
IFFICO Tokio	110.9	106.9	107.07	118.91	89.58
Reliance General	78.01	69.11	61.06	70.73	38.5
Royal Sundaram	102.73	125.81	100.65	108.95	92.53
ShriRam General	87.38	160.02	125.49	112.37	264.37
Tata AIG	62.03	78.17	79.28	85.8	77.31
Universal Sompo	16.97	30.8	37.73	42	30.99
National	95	89.94	96.83	103.36	102.24
New India	87.53	75.88	88.63	64.21	39.27
Oriental	79.57	52.75	80.99	72.61	80.98
United	80.13	88.63	93.73	74.47	53.19

Table 4: Super Efficiency Ranks of Indian Non- life Insurers

Firm/SE Rank	2008-09 Rank	2009-10 Rank	2010-11 Rank	2011-12 Rank	2012-13 Rank
Bajaj Allianz	3	5	5	6	6
Bharti AXA	16	15	16	15	15
Chola MS	5	8	11	8	3
Future Generali	14	14	14	14	13
HDFC Ergo	13	11	9	7	10
ICICI Lombard	1	3	2	4	9
IFFICO Tokio	2	4	3	1	5
Reliance General	11	12	13	12	14

Royal Sundaram	4	2	4	3	4
ShriRam General	8	1	1	2	1
Tata AIG	12	9	12	9	8
Universal Sompo	15	16	15	16	16
National	6	6	6	5	2
New India	7	10	8	13	12
Oriental	10	13	10	11	7
United	9	7	7	10	11

Table 5: Cross Efficiency Scores of Indian Non- life Insurers

Firm/CE Score	2008-09	2009-10	2010-11	2011-12	2012-13
Bajaj Allianz	89.18	90.54	86.24	85.24	75.88
Bharti AXA	6.26	24.64	22.9	33.07	30.89
Chola MS	84.37	71.09	66.96	72.24	90.25
Future Generali	29.41	33.32	30.29	46.26	36.72
HDFC Ergo	52.46	62.51	55.13	75.27	56.74
ICICI Lombard	88.9	83.74	83.1	86.3	68.99
IFFICO Tokio	96.07	91.61	90.92	93.96	82.92
Reliance General	69.06	62.94	46.99	49.93	29.4
Royal Sundaram	76.36	90.14	78.07	79.04	83.56
ShriRam General	59.74	91.29	91.43	94.09	100
Tata AIG	55.5	63.85	70.41	72.38	70.71
Universal Sompo	11.43	26.61	29.18	29.89	29.69
National	81.84	75.55	76.59	67.14	90.93
New India	66.83	54.91	59.85	52.3	37.45
Oriental	74.06	19.66	67.37	60.02	72.92
United India	71.61	66.44	65.98	62.76	49.45

Table 6: Cross Efficiency Ranks of Indian Non- life Insurers

Firm/CE Rank	2008-09 Rank	2009-10 Rank	2010-11 Rank	2011-12 Rank	2012-13 Rank
Bajaj Allianz	2	3	3	4	6
Bharti AXA	16	15	16	15	14
Chola MS	4	7	9	8	3
Future Generali	14	13	14	14	13
HDFC Ergo	13	11	12	6	10
ICICI Lombard	3	5	4	3	9
IFFICO Tokio	1	1	2	2	5
Reliance General	9	10	13	13	16
Royal Sundaram	6	4	5	5	4
ShriRam General	11	2	1	1	1
Tata AIG	12	9	7	7	8
Universal Sompo	15	14	15	16	15
National	5	6	6	9	2
New India	10	12	11	12	12
Oriental	7	16	8	11	7
United India	8	8	10	10	11

Figure1:Super Efficiency Ranks

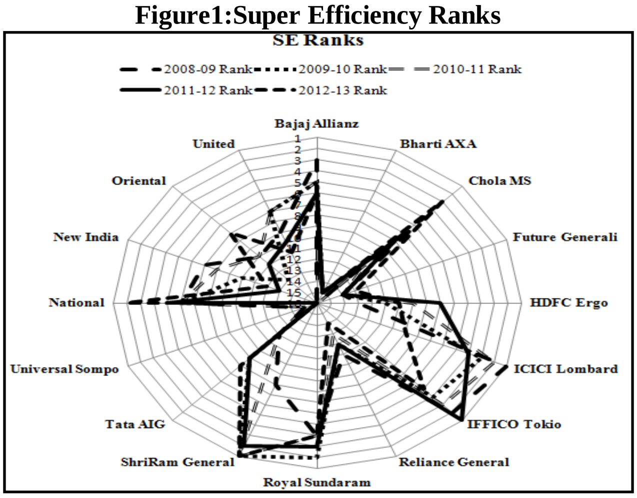
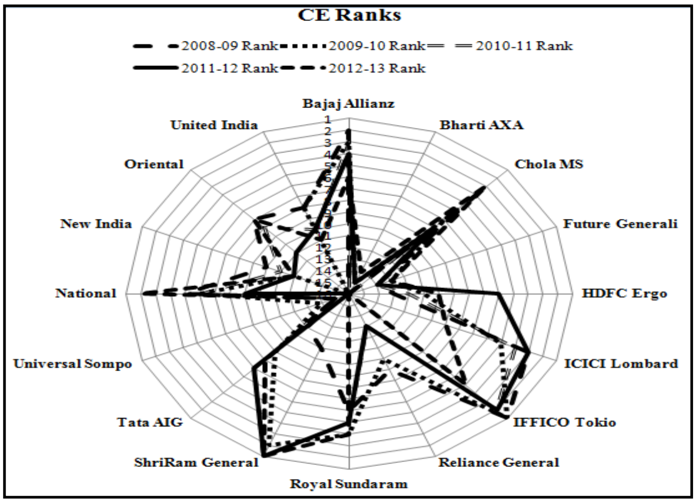


Figure2: Cross Efficiency Ranks



The Spearman's rank correlation between the super efficiency and cross-efficiency ranks for each year are given in the table

Table7: Spearman's rank correlation between the super and cross-efficiency ranks

	Cross Efficiency Ranks					
	Year	2008-09	2009-10	2010-11	2011-12	2012-13
Super Efficiency Ranks	2008-09	0.94				
	2009-10		0.93			
	2010-11			0.90		
	2011-12				0.95	
	2012-13					0.99

Source: Author's Calculation.

The correlation values between the super efficiency and cross-efficiency from the above table are showing that the ranks from super efficiency and cross-efficiency highly positive correlated. From the Figures1 and 2, the patterns of the ranks are similar overall.

VI. Conclusions

The basic DEA models do well at identifying the inefficient units, but are weak in discriminating among the efficient units. To overcome this problem, we have used effectively the cross-efficiency and super-efficiency DEA models to measure and rank the technical efficiency of Indian non-life insurance firms.

We have found that the ranks from cross efficiency and super efficiency models are highly positive correlated showing the consistency and suitability of the SE-DEA and CE-DEA models in ranking the insurance firms.From the Graph on an average Insurance firms Shri Ram General, Royal Sundaram, IfficoTokio, ICICI Lombard Bajaj Allianz, Chola MS and National Insurance are clearly efficient with top ranks of efficiency. Whereas Bharti AXA, Universal Sompo, Reliance General, Future Generali and HDFC Ergo are clearly inefficient having the bottom ranks of efficiency. The remaining firms Tata AIG, United, New India and Oriental are marginally efficient with medium level of ranks of efficiency. Through this exercise, we recommend the mathematical modelling approach to efficiency ranking using super-efficiency and cross-efficiency DEA models.

References

[1]. Charnes, A., Cooper, W. W. and Rhodes, E. (1981) "Measuring the Efficiency of Decision-Making Units", European Journal of Operations Research, 2: 429-444.
[2]. Seiford, L. M. and Zhu, J. (1999) "Infeasibility of Super Efficiency Data Envelopment Analysis Models". INFOR, 37(3): 174-187.
[3]. Sexton, T. R., Silkman, R. H. and Hogan, A. (1986) "Data Envelopment Analysis: Critique and Extensions" In R. H. Silkman (ed).
[4]. Sexton TR, RH Silkman and AJ Hogan (1986). "Data Envelopment Analysis: Critique and Extensions." in Silkman RH (eds.) Measuring Efficiency: An Assessment of Data Envelopment Analysis Jossey-Bass: 73-105.
[5]. Allen, R., Athanassopoulos, A., Dyson, R.G., Thanassoulis, E., 1997. Weights restrictions and value judgements in data envelopment analysis: evolution, development and future directions. Annals of Operations Research 73, 13–34
[6]. Doyle, J. and Green, R. (1994) "Efficiency and Cross-Efficiency in DEA: Derivations, Meanings and Uses", Journal of the Operational Research Society, 45(5): 567-578.
[7]. Andersen, P. and Petersen, N. C. (1993) "A Procedure for Ranking Efficiency Units in Data Envelopment Analysis", Management Science, 39 (10): 1261-1264.
[8]. Joy Chakraborty; Partha Pratim Sengupta(2012) "Measuring performance and efficiency growth of the selected Indian life insurance companies: A total factor productivity approach" Arth Prabhand: A Journal of Economics and Management Vol.1 Issue 6, September 2012, ISSN 2278-0629.

[9]. Mahesh Chand Garg and Deepti(2008) " Efficiency of General Insurance Industry in India in the Post-Liberalization Era: A Data Envelopment Approach" The IUP Journal of Risk & Insurance, January, 2008

[10]. Kaoru Tone, Biresh K. Sahoo (2005) "Evaluating cost efficiency and returns to scale in the Life Insurance Corporation of India using data envelopment analysis" Socio-Economic Planning Sciences 39 (2005) 261–285.

[11]. Bawa Sumninder Kaur, Kaur Navjeet(2013)"An Overview of Investment Efficiency of General Insurance Companies in India: A DEA"IIMS Journal of Management Science 4(2013), Issue : 1,88-104.

[12]. Maria Rosa Borgesi , Milton Nektariosii and Carlos Pestana Barros (2008) "Analysing The Efficiency Of The Greek Life Insurance Industry", European Research Studies, Volume XI, Issue (3) 2008.

[13]. Brockett, P. L. and Golany, B. (1996) ”Using Rank Statistics for Determining Programming Efficiency Differences in Data Envelopment Analysis“, Management Science, 42: 466-472.

[14]. Coelli, T., Rao, D.S.P., Battese, G.E. (1998) An introduction to efficiency and productivity analysis . Norwell: Kluwer Academic Publishers.

[15]. Fuentes, H., Grifell-Tatjé, E. and Perelman, S. (2001) “A Parametric Distance Function Approach for Malmquist Productivity Index Estimation” Journal of Productivity Analysis, 15(2): 79-94.

[16]. Noulas, A.G., Hatzigayios, T., Lazaridis, J. and Lyroudi, K. (2001) ”NonParametric 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.

[17]. Seiford, L. M. and Thrall, R. M. (1990), ”Recent Developments in DEA: the Mathematical Programmig Approach to Frontier Analysis”, Journal of Econometrics, 46: 7-38.