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Efficiency Analysis of Private Life Insurance Companies in India: Analysis based on DEA Model

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ABSTRACT
This paper explores the efficiency of private life insurance companies in India. After the privatisation of the insurance sector at present, i.e. in 2024, a total of 23 private life insurance companies entered India's life insurance market. So, under this circumstance, it is high time to judge the efficiency of India's private life insurance companies. How efficiently do private life insurance companies manage the insurance sector?
DEA was employed in the study to gauge the technical proficiency of Indian life insurance providers, and correlation coefficient analysis was used to establish a relationship between inputs and outputs.
Technical efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE) are measured by using DEA. To break tie position super efficiency DEA method used in next stage.
The data used in this study, which spans the last ten years from 2013-14 to 2022-23, was entirely secondary and was gathered from the IRDA official website.
Results show that the following private life insurance companies that is ABSLIC, CHSBCOLIC, HDFCLIC, ICICIPLIC, KMLIC, MXLIC, and SBILIC, are the most private life insurance-efficient companies and the TE score, PTE score, and SE score of all the above private life insurers is 1.
The most effective private life insurance provider is SBILIC, according to research.

KEYWORDS: Life insurance sector, Correlation coefficient, DEA, technical efficiency, Pure technical efficiency, Scale efficiency, Super Efficiency.

JEL Classification code: C61, C67, D24, G22,

1. INTRODUCTION

To reduce the risk to life and property insurance is used as a social device (***Vaughan, E. J., & Vaughan, T. 2007***). Life Insurance, Insurers safeguard the policyholder against a regular payment termed as a premium (***Gopalakrishna, G. 2008***). When a policyholder gets a safeguard against non-life, i.e. fire, accidents, burglary, etc., it is called non-life insurance **(*Schwab, S. J. 1986*)**.
In India, life insurance has a long history that began in the early 1800s **(*Clark, G. W. 1999*)**. Europeans founded the Oriental Life Insurance firm, India's first life insurance firm, in Calcutta in 1818 (***Kadam, R. N. 2012***). However, this firm only provided restricted services to Indians, primarily serving European consumers (***Chandrapal, J. D., & Brahmbhatt, A. C. 2015***).
The Indian Life Assurance Companies Act was created in 1870 to regulate the life insurance industry in India **(*Heller, M. 2008*)**. As a result, other Indian life insurance firms were established. The "Bombay Mutual Life Assurance Society" was founded in 1871 and covered the lives of Indians (***Sinha, T. 2007***).
In this study, we consider 21 private life insurance companies out of 23 private life insurance companies in India. Two private life insurance companies, EXLIC and SLIC are excluded because EXLIC Company is taken over by HDFCLIC. SLIC is excluded because the FGLIC of SLIC is still unclear, as the firm is still directly supervised by the IRDAI.

For the analysis, the following private life insurance providers are taken into account:

1	Aditya Birla Sunlife Insurance Company Ltd.	ABSLIC
2	Aegon Life Insurance Company Ltd.	AGLIC
3	Ageas Federal Life Insurance Company Ltd.	AFLIC
4	Aviva Life Insurance Company India Ltd.	AVLIC
5	Bajaj Allianz Life Insurance Company Ltd.	BALIC
6	Bharti AXA Life Insurance Company Ltd.	BAXALIC
7	Canara HSBC OBC Life Insurance Company Ltd.	CHSBCOLIC
8	Edelweiss Tokio Life Insurance Company Ltd.	ETLIC
9	Exide Life Insurance Company Ltd.	EXLIC
10	Future Generali India Life Insurance Company Ltd.	FGLIC
11	HDFC Life Insurance Company Ltd.	HDFCFLIC
12	ICICI Prudential Life Insurance Company Ltd.	ICICIPLIC
13	IndiaFirst Life Insurance Company Ltd.	IFLIC
14	Kotak Mahindra Life Insurance Ltd.	KMLIC
15	MaxLife Insurance Company Ltd.	MXLIC
16	PNB Metlife India Insurance Company Ltd.	PNBMILIC
17	Pramerica Life Insurance Company Ltd.	PALIC
18	Reliance Nippon Life Insurance Company Ltd.	RNLIC
19	Sahara India Life Insurance Company Ltd.	SILIC
20	SBI Life Insurance Company Ltd.	SBILIC
21	Shriram Life Insurance Company Ltd.	SHRLIC
22	Star Union Dai-ichi Life Insurance Company Ltd.	SUDCLIC
23	TATA AIA Life Insurance Company Ltd.	TATAAIALIC

Before 1999, ordinary people depended on the only public life insurance company, i.e. LICI, for life insurance. But after 1999 private life insurance companies entered the insurance market **(*Rao, D. T. 1999*)**. In the public sector, people cannot choose a life insurance company due to the monopoly of LICI as a public life insurance company (***Naib, S. 2022***). However, the situation is juxtaposed when selecting a private life insurance company (***Fernandes, P. R., & Das, L. 2013***). There, people will get multiple options to choose. People should know which life insurance company is working efficiently. This study will help us to understand which private life insurance companies are efficient and which are inefficient (***Dutta, A., & Sengupta, P. P. 2011***). It will also help us know which private life insurance company works most efficiently (***Ilyas, A. M., & Rajasekaran, S. 2019***).
Our study will help the general public and assist private life insurance companies in identifying their weaknesses.

1.1 Motivation of the Proposed Study

The private sector covers almost 40% of the life insurance market in India. This share of private life insurance companies is gradually increasing year after year. In the case of the public Life insurance sector, LICI enjoys the monopoly. But, in the case of the private life insurance sector, 21 private life insurance companies are competing with each other. So ordinary people want to know which private life insurance company works efficiently so ordinary people can trust and invest money in such a company. This study helps ordinary people to select the most efficient private life insurance companies and invest in such companies. The study also helps us to identify whether the old companies are working more efficiently or not. This study is also helpful for private life insurers to find out their efficiency.

1.2 Novelty of the present study

Instead of sampling, all the private life insurance companies are considered to evaluate efficiency scores. The DEA method has been used to measure the efficiency of private life insurance companies. The selection of input and output for DEA is based on the various literature reviews, and we also used a correlation coefficient to identify whether the selected input-output has a significant association or not.

Efficiency has been measured on constant return to scale (CRR) and variable return to scale (VRS). The study used scale-efficiency to identify the efficient private life insurance companies. Regarding the tie position in the DEA method, we used the super-efficiency score to break the tie position and choose the most efficient private life insurance companies among all the 23 private life insurance companies.

2. LITERATURE REVIEW

R P Sinha (2015) In this study, efficiency was measured in Indian life insurance firms to compare performance. The current work used a dynamic slacks-based DEA model. 15 life insurance companies are taken as samples, and the period for the study is 2005 to 2012. In contrast to traditional static DEA models, it connects the observed years through the use of a link variable, resulting in the creation of a shared benchmark.

Grmanová, Eva & Strunz, Herbert. (2017) This article seeks to ascertain the connection between insurance firms' profitability and technological efficiency. The amount of assets, ROE, and ROA were some of the metrics used to describe how profitable insurance firms were. In Slovakia, we examined fifteen business insurance providers between 2013 and 2015. DEA models were used to express the technical efficiency ratings.

Waghavkar, M. P., & Sananse, S. L. (2018) In this research, investment revenue is taken as output, and two inputs are taken: commission and running expenditures. Period was taken for the study, from 2011–12 to 2015–16. This study's main goal was to maximise output with the least amount of input. The study's findings indicate that when private enterprises were analysed group-wise, their average scale efficiency ranged from 0.8151 in 2011–12 to 0.9615 in 2015–16.

Saha and Roy (2018) In this paper, the effectiveness of 24, including both public and private life insurance firms in India, has been evaluated on the basis of DEA. The period for the study is from 2015 to 20116. The efficiency score has been calculated based on the CCR model. The paper used three inputs and three outputs.

Anandarao, et. al. (2019) To determine system and divisional efficiency ratings, this study used a two-stage Relational data envelopment analysis (DEA) to measure the efficiency. The study demonstrated that, in comparison to the firms that were dominating in the premium stage, the companies that were dominant in the investment stage retained a comparatively greater total efficiency.

SA Siddiqui (2020) The study examines the efficiency of Indian life insurance companies. The period of the study is from 2013 to 2017. The results showed that “Life Insurance Corporation” (LIC), the state-run life insurer, operated effectively during the duration of the investigation.

Sepideh Kaffash (2020) made a literature study and evaluated 132 DEA studies published in the insurance business between 1993 and July 2018. The study showed that the effectiveness of insurance businesses has not yet been impacted by recent developments like Insurtech, market transparency, and micro-insurance institutions. The study identified gaps in the body of existing literature.

A. G. et.al. (2021). The performance of life insurance firms operating in India from 2010 to 2017 was examined by the DEA method in this research. The DMU that can reduce input while keeping output at or above zero has been found using an input-oriented paradigm. The DMUs' effectiveness in reducing expenses is gauged by their efficiency scores.

Niu, G., Quinn, J. and Olinsky, A. (2022) The study used Data Envelopment Analysis (DEA) to analyse data from 2018 to 2020 from a collection of property and liability insurance businesses. A few commonly used financial indicators were compared with the computed relative efficiency. We concluded that DEA and the measurement of its relative efficiency offer a reliable indicator with particular IRIS ratios. When different ratios and change-based financial measures yield contradictory results, the approach and outcome might be applied.

Siddiqui, S. A., & Shaddady, A. (2023). This article used the DEA approach to assess the efficiency of insurance companies in India from 2017 through 2021. The study found that evaluations for cost efficiency were greater than ratings for profit efficiency.

Potluri, R. M., & Vajjhala, N. R. (2024) studied a simple inquiry using DEA for efficiency benchmarking, systematically evaluating how successfully specific industries have embraced disruptive innovations. The report highlights the various problems, possibilities, and difficulties that come with integrating these technologies, the changes that follow in the dynamics between employers and employees and the issues that governance faces. The chapter also discussed the practical applications of these technologies and their broader implications, such as cost savings, sustainability, and socially conscious business practices in the relevant industries.

3. RESEARCH GAP

Most studies consider the public and private life insurance companies in a single frame and measure their efficiency. There is a lack of focused analysis on private life insurance companies, especially post-privatization. Most studies analysed data prior to the recent growth of private life insurers in India. With 23 private life insurance companies now operating as of 2024, there is a need to assess their efficiency under the current competitive and regulatory environment. In most of the studies, the relationship between inputs and outputs has not been establised in the efficiency analysis. This leaves a gap in understanding how specific inputs drive outputs in private life insurance companies. There is a lack of measuring pure technical efficiency, technical efficiency, and scale efficiency separately, and they were not ranked according to all the efficiency scales. No such study measures efficiency separately in the super-efficiency method of DEA.

Addressing these gaps, the current study uniquely contributes to the literature by employing a super-efficiency DEA model to analyse technical, pure technical, and scale efficiency of private life insurance companies in India, incorporating recent data (2013–2023) and exploring input-output correlations to provide actionable insights for industry stakeholders.

4 OBJECTIVES OF THE STUDY

1. To study the association between input and output factors, conduct a correlation between input and output.
2. To measure the overall technical efficiency of the private life insurance companies.
3. To measure the pure technical efficiency of the private life insurance companies.
4. To measure the scale efficiency of the life insurance companies.
5. To measure the most efficient private life insurance companies in insurance activity.

5. RESEARCH METHODOLOGY

Different companies worked in different situations, so to find out the efficiency we used the Data Envelopment Analysis (DEA) to find out the efficiency score **(*Ji, Y. B., & Lee, C. 2010*)**.

Efficiency is measured by the ratio of output and input (***Olesen, O. et al. 2017***). Efficiency is the capacity of a business to provide desired goods or services with the least amount of waste, costs, or resources **(*Sengupta, J. K. 1982*)**. Efficiency increases with more production per unit of input variables. The insurance sector has tried to strengthen its position in the market to run as efficiently as possible in this age of competition **(*Wei, C. K., Chen, L. C., Li, R. K., & Tsai, C. H. 2011*)**. Here, efficiency is measured based on technical efficiency, Pure Technical efficiency, and scale efficiency (***Farrell, M. J. 1957***).

The study is based on the input-oriented method, which means, assuming the DMU is running at optimal scale, quantifies how successfully a DMU uses its inputs to create outputs (***Asmild, M. et.al. 2007***). To find out the efficiency score both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) models are used (***Panayides, P. M., et..al. 2009***).

Pure Technical Efficiency based on: Acknowledges that doubling inputs may not always result in doubling outputs (owing to increasing, constant, or falling returns to scale) (***Abel, S., & Bara, A. 2017***). This allows for differing efficiency at different scales.

The ratio of a DMU's technical efficiency under the VRS assumption to that under the CRS assumption is known as scale efficiency (***Chen, K., & Zhu, J. 2019***). It gauges a DMU's proximity to functioning at the scale size at which it would be most productive (i.e., have constant returns to scale (***Wei, C. K., et. al. (2011***).

The correlation test justifies the significance of Input and Output.

Efficiency is measured in both constant return to scale and variable return to scale. The final ranking is done based on scale efficiency.

5.1 Data source: Secondary Data has been used for the last 10 years, i.e., from 2013-14 to 2022-23 from IRDA.

5.2 Research Variables: To examine efficiency, we use the DEA approach. In DEA analysis, estimate efficiencies and compare the input with the generated output. The DEA analysed the effectiveness of private life insurance companies from 2013 to 2022.

Inputs and outputs are selected based on the literature review. To measure insurance efficiency the following inputs and outputs are considered.

INPUT	**OUTPUT**
Operating expenses (I1)	Investment income (O1)
Share capital (I2)	Net premium (O2)
Investment (I4)	Profit after tax (O3)

5.3 HYPOTHESIS

H0: There is no significant relation between input and output.
H1: There is a significant relation between input and output.

6. DATA ANALYSIS

Table 1. Input and Output Data

	OP EXP{I}	SH CAP{I}	INVEST MENT {I}	INVEST INCOME {O}	PAT{O}	NET PREMIUM {O}
ABSLIC	1167.70	2313.36	16737.90	3755.21	168.64	7021.99
AGLIC	202.64	2085.05	1505.76	220.17	-78.59	417.91
AFLIC	248.88	901.07	5742.02	677.28	101.17	1521.83
AVLICL	292.24	2022.62	5514.66	917.30	-22.08	1256.79
BALIC	1784.99	8978.76	34602.29	5599.61	657.78	8826.64
BAXALIC	643.08	2892.04	4829.18	571.48	-153.96	1615.26
CHSBCLIC	452.33	1156.59	6861.02	1407.80	104.05	3243.55
ETLIC	363.48	1721.15	2204.81	240.69	-195.85	671.77
FGLIC	427.23	1823.81	3302.73	323.15	-119.37	941.72
HDFCLIC	3690.23	6611.75	67171.17	11304.99	1083.03	25931.50

ICICIPLIC	2594.10	7150.65	51430.18	14233.90	1288.78	24757.21
IFLIC	409.04	848.46	8649.61	1114.92	-13.55	2881.78
KMLIC	1203.52	2775.88	17697.72	2630.44	472.15	7072.01
MXLIC	2046.85	2652.06	43374.15	5212.39	491.75	12759.84
PNBMLIC	893.92	2068.50	14587.04	1785.13	73.86	4026.77
PALIC	358.89	1160.51	3549.21	297.29	34.01	1024.68
RNLIC	1100.12	1900.31	13868.54	2007.30	51.99	4085.13
SBILIC	2043.52	7555.44	73110.02	12527.61	1195.77	29611.86
SHRLIC	422.65	610.21	3868.88	342.13	65.22	1396.73
SUDCLIC	356.63	608.93	6276.54	773.46	49.60	2071.25
TATAAIALIC	1487.87	2126.32	21310.86	3178.88	172.37	6151.47

The above table shows the averages of the inputs and outputs of the ten years, i.e 2013-14 to 2022-23 In DEA analysis, isotonicity relations are assumed. Here any specific method has not been used to select input and output (***Wu, D., Li, H., Huang, Q., Li, C. and Liang, S., 2024***).
So, the input and output factors were selected judiciously based on various literature studies and according to the intermediation approach (***Golany, B. and Roll, Y., 1989***). Further, correlational analysis is used to identify whether such selection of input and output variables is justified or not **(*Lim, S.M., 2009***).

Table 2. Correlation coefficient

Correlations							
		OP EXP{I}	SH CAP{I}	INVESTMENT{I}	INVEST INCOME{O}	PAT{O}	NET PREMIUM{O}
OP EXP {I}	Pearson Correlation	1	.799**	.924**	.913**	.894**	.895**
	Sig.		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
SH CAP {I}	Pearson Correlation	.799**	1	.844**	.869**	.865**	.816**
	Sig	**0.000**		**0.000**	**0.000**	**0.000**	**0.000**
INVESTMENT {I}	Pearson Correlation	.924**	.844**	1	.977**	.963**	.987**
	Sig.	**0.000**	**0.000**		**0.000**	**0.000**	**0.000**
INVEST INCOME {O}	Pearson Correlation	.913**	.869**	.977**	1	.971**	.983**
	Sig.	**0.000**	**0.000**	**0.000**		**0.000**	**0.000**
PAT {O}	Pearson Correlation	.894**	.865**	.963**	.971**	1	.960**
	Sig.	**0.000**	**0.000**	**0.000**	**0.000**		**0.000**

NET PREMIUM {O}	Pearson Correlation	.895**	.816**	.987**	.983**	.960**	1
	Sig.	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation coefficient of the table shows that there is a significant association between inputs and outputs.

6.1 HYPOTHESIS TESTING

H_0: There is no significant association between input and output. (R is not significantly different from zero.
H_1: The association between input and output is significant. (R is significantly different from zero).
We calculate the correlation coefficient, i.e. r and then do a t-test to determine the significance of the association between input and output. Compare the computed t value with the table value of t. In each case calculated value of t > tabulated value of t. So, H_0 is not accepted.
In Jamovi software, we calculate the P value to make a significant test. If the P value is less than significance, label i.e sig level is 0.05; then we reject the H0. So, for the inputs and outputs, we rejected the null hypothesis. And we confirmed a significant relationship between the selected inputs and outputs. The factors of inputs and output satisfy the requirement of isotonicity and are suitable for our study.

6.2 Efficiency Measurement

The 21 private life insurance firms' insurance efficiency is evaluated using Data Envelopment Analysis. When various inputs and outputs make comparisons challenging, data envelopment analysis (DEA), a linear programming-based approach, is used to measure the relative performance of organisational units (***Cohen, J. et al., 2013***).
A fraction whose numerator and denominator contain choice factors is nonlinear. Given that we are employing a linear programming approach, we must first linearise the formulation such that the objective function's denominator is one and then maximise the numerator (***Charnes, A., Cooper, W.W. and Rhodes, E., 1978***).
In DEA models, we measure the best efficient decision-making unit by putting weights into inputs such as $X_1, X_2, ..., X_n$, and weights in outputs $Y_1, Y_2, ..., Y_n$ so that each decision-making unit becomes the most efficient DMU (***Sanjeev, G.M., 2006***).
In DEA models, the best decision-making unit is identified by giving weightage to the inputs and outputs (***Banker, R.D., Cooper, W.W., Seiford, L.M., Thrall, R.M. and Zhu, J., 2004***). For DMUo, the basic model was calculated as follows:

$\text{Max } z(u, v) = \sum_r u_r y_{ro} / \sum_i v_i x_{io}$

$\sum_r u_r y_{ro} / \sum_i v_i x_{io} \leq i$ for j -1, 2… n

$u_i, v_i \geq 0$ for all i and r.

$\text{Max } z = \sum^{s}_{r=1} \mu_r y_{ro}$ subject to

$\sum^{s}_{r=1} \mu_r y_{rj} - \sum^{m}_{i=1} v_i x_{ij} \leq 0$

$\sum^{m}_{i=1} v_i x_{io} = 1$

$\mu_r, v_i \geq 0$

Here, 21 private life insurance companies are considered as DMUs.

6.3 Technical efficiency – “CCR model” (Charnes, Cooper and Rhodes, 1978)

DEA analysis is done based on two types of return to scale. One is a Constant return to scale (CRS), and the other is a variable return to scale (VRS). CRS assumes the DMU's efficiency and scalability have no meaningful correlation (***Banker, R.D., et. al. 2004***). So, CRS measures the technical efficiency (TE) of the DMUs (***Banker, R.D., Charnes, A. and Cooper, W.W., 1984***).

Mathematical Formulation of TE (Input-Oriented DEA):

Suppose there are m DMUs, each using mmm inputs to produce s outputs. The technical efficiency of a specific DMU, say DMU o, is obtained by solving the following linear programming problem:

Min θ

Θ, λ

Subject to:

$\sum_{j=1}^{n} \lambda j \; xij \; <= \theta \; x_{io,}$ i=1, 2, … m

$\sum_{j=1}^{n} \lambda j \; yrj \; <= \theta \; y_{ro,}$ r=1, 2, … s

$\lambda \geq 0$ j=1,2, … n

x_{ij} the amount of input i used by DMU j

y_{rj}_{rj}yrj is the amount of output r produced by DMU j,

θ is the technical efficiency score of DMU o,

λ are the weights assigned to the peer DMUs

Table 3. TE (technical efficiency score) based on CRS assumption with CRR model

DMU	TE	RANK
ABSLIC	**1**	**1**
CHSBCLIC	**1**	**1**
HDFCLIC	**1**	**1**
ICICIPLIC	**1**	**1**
KMLIC	**1**	**1**
MXLIC	**1**	**1**
SBILIC	**1**	**1**
BALIC	0.8728	8
AFLIC	0.867	9
TATAAIALIC	0.8628	10
IFLIC	0.8516	11
SUDCLIC	0.8496	12
SHRLIC	0.8303	13
AVLIC	0.7346	14
BAXALIC	0.7075	15
RNLIC	0.6899	16
AGLIC	0.6557	17
ETLIC	0.6445	18
PNBMLIC	0.6245	19
PALIC	0.6143	20
FGLIC	0.6031	21

From the above efficiency score, it has been observed that different life insurance companies like CHSBCLIC, HDFCLIC, ICICIPLIC, ABSLIC, KMLIC, MXLIC, and SBILIC the insurance sector most efficiently. They are scored 1. However, FGLIC has scored the lowest efficiency score.

6.4 Pure Technical Efficiency – "BCC model" (Banker, Charnes and Cooper, 1984)

Now, we find the insurance efficiency score under the assumption of VRS, and VRS followed the BCC model. BCC model for finding out efficiency score was developed by Banker, R.D., Charnes, A. and Cooper, W.W., in 1984. This model measures the pure technical efficiency score (***Banker, R.D., Charnes, A. and Cooper, W.W., 1984***).

Min θ

Θ, λ

Subject to:

$\sum_{j=1}^{n} \lambda j \; xij \; <= \theta \; x_{io,}$ $\quad i=1, 2, \ldots m$

$\sum_{j=1}^{n} \lambda j \; yrj \; <= \theta \; y_{ro,}$ $\quad r=1, 2, \ldots s$

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

$\lambda_j \geq 0$ $\qquad j=1,2, \ldots n$

x_{ij} represents the inputs of DMU j

y_{rj}_ represents the output of DMU j,

θ is the pure technical efficiency score of DMU o,

λ are the weights assigned to each DMU

The constraint $\sum_{j=1}^{n} \lambda j = 1$ introduces variable returns to scale (VRS) and ensures that the analysis is not influenced by scale effects.

Table 4. PTE (Pure technical efficiency score) based on VRS assumption with BCC model

DMU	PTE	RANK
ABSLIC	**1**	**1**
AGLIC	**1**	**1**
AFLIC	**1**	**1**
AVLIC	**1**	**1**
CHSBCLIC	**1**	**1**
HDFCLIC	**1**	**1**
ICICIPLIC	**1**	**1**
KMLIC	**1**	**1**
MXLIC	**1**	**1**
SBILIC	**1**	**1**
SHRLIC	**1**	**1**
SUDCLIC	**1**	**1**
IFLIC	0.9854	13
PALIC	0.9814	14
ETLIC	0.9766	15
TATAAIALIC	0.8877	16
BALIC	0.8751	17
FGLIC	0.8137	18

BAXALIC	0.7817	19
RNLIC	0.7246	20
PNBMLIC	0.6385	21

From the viewpoint of pure technical efficiency, we found that 12 life insurance companies es scored 1. That means under VRS assumption, ABLIC, AGLIC, AFLIC, AVLIC, CHSBCLIC, HDFCLIC, ICICIPLIC. KMLIC, MXLIC SBILIC, SRLIC, and SUDCLIC manage insurance most efficiently. However, PNBMLIC and MLIC scored the lowest in this technical measurement format.

6.5 Scale efficiency (SE= TE / PTE)

Technical efficiency is under the assumption that CRS measures operational efficiency as well as scale efficiency.

Whereas Pure technical efficiency is under the assumption of VRS, that assumption presents efficiency without considering the scale of operation. It provides inefficiency resulting from underperformance.

PTE >= TE

If DMU is fully efficient in both TE and PTE then it is said that DMU is operating in the most productive scale that is 100% scale efficiency.

Table 5 TE, PTE, and SE score

DMU	**TE**	**PTE**	**SE**	**RANK (Based on SE)**
ABSLIC	**1**	**1**	**1**	**1**
CHSBCLIC	**1**	**1**	**1**	**1**
HDFCLIC	**1**	**1**	**1**	**1**
ICICIPLIC	**1**	**1**	**1**	**1**
KMLIC	**1**	**1**	**1**	**1**
MXLIC	**1**	**1**	**1**	**1**
SBILIC	**1**	**1**	**1**	**1**
BALIC	0.8728	0.8751	0.99737	8
PNBMLIC	0.6245	0.6385	0.97807	9
TATAAIALIC	0.8628	0.8877	0.97195	10
RNLIC	0.6899	0.7246	0.95211	11
BAXALIC	0.7075	0.7817	0.90508	12
AFLIC	0.867	1	0.867	13
IFLIC	0.8516	0.9854	0.86422	14
SUDCLIC	0.8496	1	0.8496	15
SHRLIC	0.8303	1	0.8303	16
FGLIC	0.6031	0.8137	0.74118	17
AVLICL	0.7346	1	0.7346	18
ETLIC	0.6445	0.9766	0.65994	19
AGLIC	0.6557	1	0.6557	20
PALIC	0.6143	0.9814	0.62594	21

Table 6. Efficient and Inefficient Private Life Insurance Companies Regarding Insurance

PTE = SE = 1 i.e. TE = 1 Both technical and scale-efficient private life insurance companies in Insurance activities	**ABSLIC, CHSBCLIC, HDFCLIC, ICICIPLIC, KMLIC, MXLIC, SBILIC.**
PTE =1, SE < 1 i.e., TE < 1 Technical efficient but not scale-efficient private life insurance companies regarding insurance activities.	AGLIC, AFLIC, AVLIC, SHRLIC, and SUDCLIC.
TE< 1, PTE < 1, SE < 1 Both technical and scale-inefficient life insurance companies	PALIC, ETLIC, ABSLIC, TATAAIALIC, FGLIC, BALIC, BAXALIC, RNLIC, PNBMLIC

From the above efficiency score, it has been noticed that almost 7 private life insurers have an efficiency score of 1.

So, from the DEA, we cannot identify the best one because seven private life insurance companies are ranked equally, that is, 1 (100% efficiency). To break the position between the 7 DMUs, we use super-efficiency DEA (***Andersen, P. and Petersen, N.C., 1993***).

Super efficiency model by Anderson and Peterson (***Lovell, C.K. and Rouse, A.P.B., 2003***).

$\lambda = \min [\ \varphi - \mathcal{E}\ (\ d^T{}_1\, s + d^T{}_2\, s^+\ )]$

s.t Σ 1=1 , $d \neq k$ $\quad \lambda_1\, x_1 + s = \varphi_{xk}$;

$\Sigma_1{}^m$ =1, $d \neq k$ $\quad \lambda_1\, x_1 - s^+ = Y_k$;

$\lambda\ .\ s^+\ ,\ s \geq 0$

Table 7. SUPER EFFICIENCY SCORE based on CRS, VRS, and SE

DMU	TE	PTE	SE=TE/PTE	RANK (Based on SE)
SBILIC	1.8558	big	#infinte	1
HDFCLIC	1.0188	1.0202	0.9986	2
BALIC	0.8728	0.8751	0.9974	3
MXLIC	1.2267	1.2436	0.9864	4
KMLIC	1.3012	1.3256	0.9816	5
PNBMLIC	0.6245	0.6385	0.9781	6
TATAAIALIC	0.8628	0.8877	0.9719	7
ABSLIC	1.0352	1.0693	0.9681	8
RNLIC	0.6899	0.7246	0.9521	9
ICICIPLIC	1.2216	1.3126	0.9307	10
CHSBCLIC	1.139	1.232	0.9245	11
BAXALIC	0.7075	0.7817	0.9051	12
IFLIC	0.8516	0.9854	0.8642	13
FGLIC	0.6031	0.8137	0.7412	14
AVLIC	0.7346	1.048	0.7010	15
SUDCLIC	0.8496	1.2619	0.6733	16
ETLIC	0.6445	0.9766	0.6599	17
PALIC	0.6143	0.9814	0.6259	18
SHRLIC	0.8303	1.3985	0.5937	19
AFLIC	0.867	1.7426	0.4975	20
AGLIC	0.6557	1.9197	0.3416	21

The above table shows that the SBILIC maintains insurance activity most efficiently among the private life insurance companies, followed by HDFCLIC and BALIC, respectively. This super efficiency score breaks down the tie position of the efficiency score 1.

7 FINDINGS

1) The correlation between the following input and output is statistically significant.

Table 8. Selected input and output for DEA

INPUT	OUTPUT
Operating expenses	Investment Income
Share capital	Net premium
Investment	Profit after tax

2) ABSLIC, CHSBCLIC, HDFCLIC, ICICIPLIC, KMLIC, MXLIC, and SBILIC are found to the efficient under technical efficiency because the TE of these countries is 1.
3) ABSLIC, CHSBCLIC, HDFCLIC, ICICIPLIC, KMLIC, MXLIC, SBILIC, AGLIC, AFLIC, AVLIC, SHRLIC, and SUDCLIC. are found to the efficient under pure technical efficiency. The PTE of these countries is 1
4) The following private life insurance companies have the right size of insurance operation under scale efficiency measures: **ABSLIC, CHSBCLIC, HDFCLIC, ICICIPLIC, KMLIC, MXLIC,** and **SBILIC.** The scale efficiency of these countries is 1.
5) To break the tie between the most efficient private life insurers' super-efficiency DEA model under the CRS assumption and the VRS assumption applied.
6) SBILIC is the most efficient private life insurance company.

8. CONCLUSION

- Based on various literature reviews, We have taken the three inputs and three outputs for measuring insurance efficiency.

The inputs are: 1) Operating Expenses
2) Share Capita
3) Investment Amount
The outputs are 1) Profit After Tax.
2) Investment Income
3) Net Premium.

- The selection of input and output also satisfies the thumb rule i,e, Minimum number of DMUs = Max {m x s, 3 (m + s***)}(Toloo, M. and Tichý, T., 2015***).

Where m = number of inputs and s = number of outputs.
Here minimum number of DMU should be max {3 x3, 3 (3+3)} i.e. 18 and we taken 21 DMU's

- Measure the overall technical efficiency score by the CCR model of DEA assuming the constant return to scale. We found that seven private insurance companies are the most efficient in insurance activities, with an efficiency score of 1.
- Measure the pure technical efficiency score by the BCC model of DEA, assuming the variable return to scale. We found that 12 private life insurance companies are the most efficient, with an efficiency score of 1.
- However, overall technical efficiency measures both operational efficiency and scale efficiency. So, we measured the scale efficiency by dividing the TE by PTE. In scale efficiency, we found the seven private life insurance companies are the most efficient with an efficiency score of 1.

- Among the efficient private life insurance companies, "SBILIC" is the most efficient private life insurance company because "SBILIC" has a super efficiency scale efficiency score of infinite, a super efficiency TE score of 1.8588 and a super efficiency PTE score is also infinite.
- HDFCLIC is the 2nd efficient private life insurance company in insurance activity with a super efficiency scale efficiency score of 0.9986, followed by Bajaj Alliance Life Insurance Company (super scale efficiency score 0.9974), Max Life (super scale efficiency score 0.9964), KMLIC company (score 0.9916 and in 6th position PNBMLIC with a super scale efficiency score of 0.9781.

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