Chapter 7: Research Methodology

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7.1 INTRODUCTION

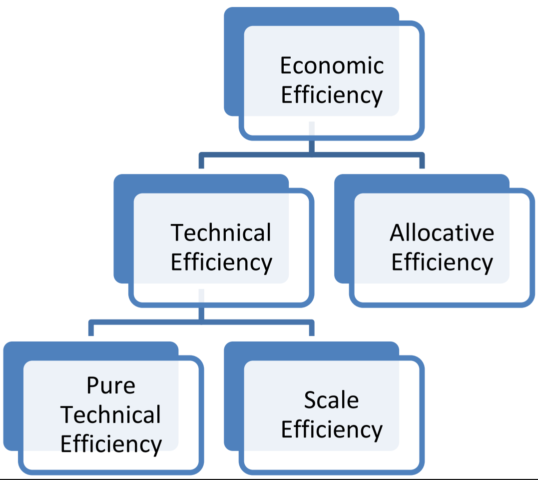
The study uses Data Envelopment Analysis (DEA) to measure the relative efficiency of life insurers in India. Relative efficiencydetermines the efficiency position of an insurer with respect to another. There arevariousindustries like banking, insurance, power & electricity, non-banking finance companies, microfinance, education and even medical institutionson which efficiency studies have been applied by researchers.

However, efficiency analysis has not gained much importance in research studies in India. So there was a dearth of research articles in this particular area. So in absence of rich literature in the field of life insurance, particularlyby applying efficiency determination, this study was foundutmost necessary.

7.2 DATAENVELOPMENT ANALYSIS (DEA) TECHNIQUE

The main focus of this research is to measure and examine the efficiency of Life Insurancefirms operating in India. The concept of efficiency is primary an engineering concept, commonly used to describe the level of performance of a production unit in terms of its utilization of resources in generating outputs. Modern approach towards efficiency measurement is starting from the concept of efficiency of farrell's (1957). Michael j. Farrell, greatly influenced by Koopman's (1951) formal definition and Debreu's (1951) measure of technical efficiency has introduction a method to decompose the overall efficiency of a production unit into its technical and allocative components. However the different efficiency concepts are.

<u>Different Concepts of Efficiency</u>



Economic efficiency or overall efficiency means producing the “right” (Allocative Efficiency) amount in the “right” way (Technical Efficiency). Technical efficiency and allocativ efficiency together form economic efficiency also called as x-efficiency.Overall efficiency i.e., economic efficiency refers to situation in which (with the give state of technology) it is impossible to generate a larger welfare total from the available resource. It means when more output cannot be obtained without increasing the amount of inputs. Production proceeds at the lowest possible per-unit cost. Profit maximization requires a firm to product the maximum output the using given level of the inputs employed (i.e. be technically efficiency), use the right mix of input in light of the relative price of each input (i.e.input allocative efficiency) and product the right mix of output given the set of prices (I.e. output allocative efficient). However, an organization will only be economic efficient if is the both technically and allocatively efficient.

Allocative efficiency refers to whether inputs, for a give level of output and set of input price are chosen to minimize the cost of production. It refers to ability to combine inputs and outputs in the optimal proportion in the light of prevailing prices. It refers to allocative of resource that allows maximum possible benefit or utility from the available resource.

Technical Efficiency – The most common efficiency concept is technical efficiency: the conversion of inputs into outputs. Technical efficiency considers technological aspect as production. It is therefor, a measure of how well the transformation prosess (from input to output) is performing. In other words, it refers to ability to avoib aster by producing as much output as input usage alloes or by using as little input as output allows.

Koopmans defined technical efficiency as a feasible input/output vector where it is technologically impossible to increase any output without simultaneously reducing another output.This analogy holds fir a reduction in any input or both a reduction in any input and an increase in any output. Farrell measured technical inefficiency as the maximum equi-proportional reduction in all inputs consistent with with equivalent production of observed output.

Thus, technical efficiency measurement can have output orientation and input orientation. Input oriented efficiency means minimization of inputs with producing at least the given level of outputs. Outputs oriented efficiency means maximization of outputs with using given level of inputs. Managerial practice and the scale or size of operation affect technical efficiency, which is based on engineering relationship but not on price on costs. Technical efficiency therefore consists of pure technical efficiency and scale efficiency. Present study deals with technical efficiency which is based on input-output configuration.

Efficiency Measurement Techniques

There are basically two efficiency measurement techniques: Accounting Measures and economic measures.

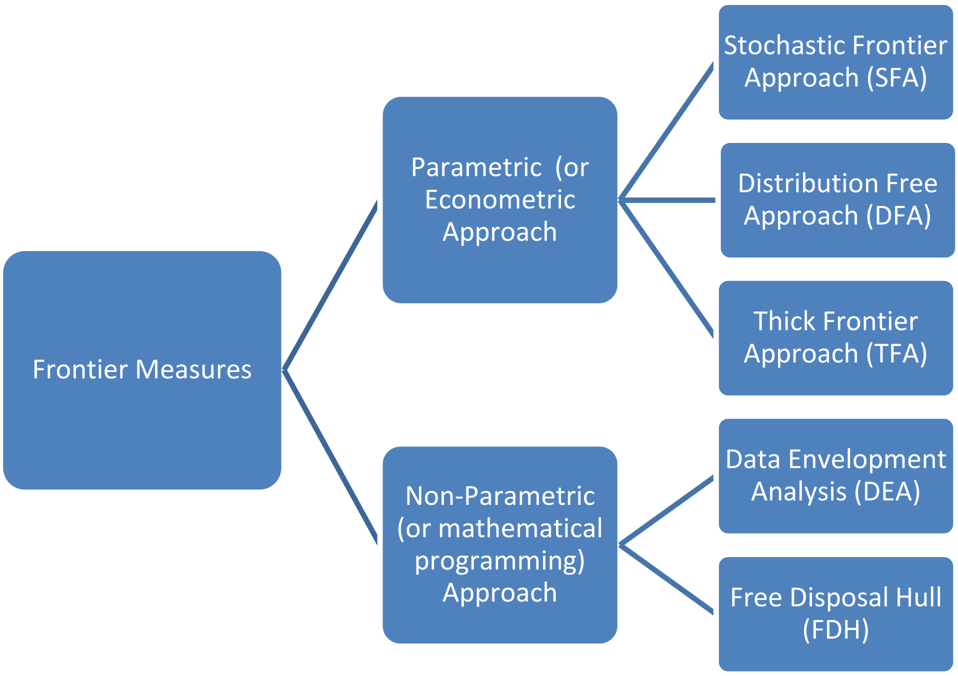
Accounting Measures of Efficiency

The Earliest technique to asset the performances of business units is ratio analysis which examines the financial statements of individual firms and comparing them with a benchmark. These ratios are popular in financial analysis and even in economic literature only because of easy understanding. But analysis based on ratio is suffering from accounting biases. That is, accounting practices and norms in different environment differ significantly and hence ratios computed from two business units operating in differing economic environment may not be suitable for drawing economic conclusions. Besides, this technique fails to take into account the fact that banks produce multiple outputs from multiple inputs and consistent aggregation is not possible (See, for example, Barnes6 , 1987; smith7, 1990). The short coming of such a descriptive and static analysis of the data is overcome by later researchers with the use of parametric and non-parametric techniques.

Economic Measures of Efficiency

Economic measures estimate various efficiencies with broadly two types of approaches- parametric and non-parametric. Parametric and non-parametric techniques are actually frontier techniques which are highlyaccepted and widely used in the field of efficiency studies. The frontier techniques have the advantages that convey the information of many operational ratios in a single index, thus permitting ranking of decisions-making units (DMUs) and summarizing of multiple possibly qualitative characteristic in a quantitative way. The various modern techniques of efficiency measurement are as follows:

Frontier Approaches for Measuring of Efficiency



The parametric and non-parametric technique differs mainly in how they handle random error and their assumption regarding the shape of the efficient frontier. The parametric stochastic frontier approach (SFA) and the no-parametric data envelopment analysis (DEA) are the most used tools to measure efficiency, taking into account that the literature considers both technique as equally satisfactory. As stated by Berger and Humphrey(1997), there is no consensus on the preferred method for determining the best-practice frontier against which relative efficiencies are measured. Berger and Mester (1997) find that it general the choice of measurement technique and functional form does not make a substantial difference in determining the average efficiency for the banking sector or raking of individual banks. We prefer to the DEA approach as we consider it to be a more appropriate tool in our analysis since it does not require an assumption of a functional form for the frontier relation to given specification of inputs and outputs of the sample composed of bank of different sizes, types and ages. Thus, DEA is an appropriate technique for this study as is fulfills the objective of estimating and examining technical efficiency of the Indian Bank and ranking them. It also enables to give as insight into efficiency of the banks.

<u>Data Envelopment Analysis</u>

Data Envelopment Analysis (DEA) is a non-parametric performance assessment methodology originally designed by charnes, Cooper and Rhodes (1978) to measure the relative efficiencies of organizational units or decision making units (DMUs). This technique aims to measure how efficiently a DMU uses the resources available to generate a set of outputs. The DEA approach applies linear programming technique to observe inputs consumed and outputs produce by decision-making units and constructs an efficient production frontier based on best practices. Each DMU's efficiency is then measured relative to this frontier.

DEA is defined by Giokas (1997) as follows:

"DEA measures relative efficiency [of DMUs] by estimating an empirical production function which represents the highest values of outputs/benefit that could be generated by inputs/resources as given by a range of observed input/output measures during a common time period"

DEA is a non-parametric linear programming based data analytic technique for measuring and evaluating relative efficiency of a homogeneous set of units termed as decision making units (DMUs) which use variety of identical inputs to produce variety of identical outputs. DEA is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called decision making units (DMUs) which convert multiple inputs into multiple outputs DEA is an optimization method of mathematical programming to generalize the farrell's (1957) single-outputs single-inputs technical-efficiency measure to multiple-output and multiple-inputs case by constructing a frontier of the best practice DMUs established mathematically by the ratio of weighted sum of outputs to weighted sum of inputs sum of inputs from the identical inputs outputs data set available from the DMUs under evaluation and to estimate efficiency of an DMU relative to the constructed frontier. Thus, DEA is a mathematical liner programming approach to frontier analysis. The estimated frontier of the best practice DMUs is also referred to as efficient or envelopment surface, In DEA literature, DMUs lie on the frontier are technically efficient having efficiency score equal to 1 and the DMUs lie off the frontier are technically inefficient having efficiency score between 1 and 10.

Importance of DEA in Banking Efficiency Measurement

DEA with 30 years of journey since 1978 is now a very popular and well accepted methodology in the field of efficiency measurement and improvement of the units using multiple inputs to produce multiple outputs. DEA was firstly applied by Sherman and Gold(1985) for assessing the efficiency of bank branches and, thereafter, it proved a very promising tool for monitoring the efficiency in banking industry. Of the 122 studies reviewed in the extensive survey carried out by Berger and Humphrey (1997) on efficiency of depository financial institutions in 21 countries, 62 studies (i.e., just over 50%) employed DEA to examine the efficiency of the banking sector. The connotation of this reference is that over the years, DEA has emerged as a well accepted and popular technique for evaluating the efficiency of the banking system. Its popularity as an accepted method of efficiency analysis can also be realized from huge DEA bibliography database also

Strengths and weaknesses of DEA

Strengths

- DEA produces a single score for each unit rather than population average, which makes the comparison easy. DMUs are directly compared against a peer or combination of peers.
- Its main strength lies in its ability to handle multiple inputs and outputs situation effectively i.e. to capture the multidimensional nature (of inputs/outputs) in the production process which is the prevalent characteristics of many units under evaluation.
- It places no restrictions on the functional form of the production relationship. That is it doesn't require an assumption of a functional form relating inputs to outputs.
- DEA modeling allows the analyst to select inputs and outputs in accordance with a managerial focus.
- Furthermore, the technique works with variables of different units (unit's invariance) without the need for standardization. There is as such no limit to the number of inputs and outputs. This is not possible through traditional ratio analysis.
- There is no requirement for any *a priori* views or information regarding the assessment of the efficiency of DMUs. The weights for outputs and inputs are obtained by calculating the DEA models, rather than being given artificially
- Another advantage of DEA that attracts analysts and management is its ability to identify the potential improvement for inefficient units by providing both the sources and the amount of inefficiency such as pure technical and mix inefficiencies. Moreover, the reference set used to benchmark these inefficiencies are also indentified. A deficiency of the econometric approaches is their inability to identify sources and estimates the inefficiency amounts

associated with these sources. Hence, no clue as to corrective action is provided even when the inefficiencies are present.

Weaknesses

- The lack of allowance for statistical noise is widely regarded as the most serious limitation of DEA because this puts a great deal of pressure on users of this technique to collect data on all relevant variables and to measure them accurately.
- DEA is good at estimating "relative" efficiency of a DMU but not "absolute" efficiency. In other words, it can tell you how well you are doing compared to your peers but not compared to a "theoretical maximum."
- Since DEA is a nonparametric technique, statistical hypothesis tests are difficult.
- Results are sensitive to the selection of inputs and outputs.

<u>DEA Models</u>

There is variety types of DEA models developed in the DEA literature since 1978. There are two approaches in DEA models: radial and non radial. Differences exist in the characterization of input or output items. In DEA literature, two models namely CCR model (named after Charnes, Cooper and Rhodes, 1978) and BCC model (named after Banker, Charnes and Cooper, 1984) are called basic DEA models. These models which are redial measure of efficiency are of two types – input oriented and output oriented.

Input oriented technical efficiency aims at reducing input amounts as much as possible while keeping at least the present output levels and output oriented technical maximizes the output level while using at least the present input levels.

CCR and BCC Models

The studyhas utilized two most popular and widely used basic DEA models-input oriented CCR model and input oriented BCC models to estimate the bank wise level of relative technical efficiency. CCR model measures the efficiency called overall technical efficiency (OTE) and BCC model measures efficiency called pure technical efficiency (PTE). OTE and PTE allow to measure scale efficiency (SE). SE = OTE/PTE. So, using these CCR and BCC models the study has estimated three types of efficiencies: OTE, PTE and SE for individual banks.

The CCR model assumes constant returns to scale so that all observed production combinations can be scaled up or down proportionally. This constant returns-to-scale DEA frontier is derived simply by the ray through the origin passing through point B. The DEA-BCC model, on the other hand, allows for variable returns to scale and is graphically represented by the piecewise linear convex frontier. The areas to the right of the two frontiers represent production possibility set (PPS). CCR and BCC models define different production possibility sets and efficiency results.

The important aspects of DEA methodology based on CCR & BCC models are:

- Reference set and improvement in efficiency i.e. projection of inefficient DMUs.
- Returns-to-Scale and
- Decomposition of technical efficiency

Mathematical Formulation CCR and BCC Models

Graphical presentation con not be used for frontier analysis in case of multiple inputs and multiple outputs. Hence a general mathematical linear programming based formulation of the frontier analysis was developed by Charnes et al. (1978) after 20 years of frontier analysis technique described by Farrel in 1957. The authors also coined the name Data Envelopment Analysis.

CCR Model

Assuming that there are n MDUs to be evaluated [DMUj (j = 1, 2…n)]. Each DMU consumes m different inputs of identical nature for all DMUs [x_{ij} (i = 1, 2 ….,m)] to produces ‘s’ different outputs of identical nature for all DMUs [y_{rj} (r = 1, 2 …..,s)]. x_{ij} and y_{rj} are assumed to be positive i.e. $x_{ij} \geq 0$ and $y_{ij} \geq 0$ and further assumption is that each DMU has at least one positive input and one positive output value. Given the data, the efficiency of DMU_k can be measured by the following programming

$$\underset{(\theta, \lambda_j, s_i^-, s_r^+)}{\text{Min}}\ \theta_k - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \qquad (1)$$

Subject to

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^+ = \theta_k x_{ik} \qquad i = 1,2,\ldots,m.$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{rk} \qquad r = 1,2,\ldots..,s.$$

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

s_i^+, $s_r^+ \geq 0$ for all i and r.

x_{ij} = Amount of input of i utilized by the j[th] DMU

y_{rj} = Amount of output of r produced by the j[th] DMU

x_{ik} = Amount of input of i utilized by DMU_k

y_{rk} = Amount of output of r produced by DMU_k

θ_k = efficiency score of DMU 'k' being evaluated

λs represent the dual variables which identify benchmarks for inefficient units.

Slack variables - s_i^- (input slacks), s_r^+ (output slacks)

Here $\mathcal{E} > 0$ is non-Archimedean element defined to be smaller than any real number and to be accommodated without having to specify the value of $\mathcal{E}$.

Above mathematical formulation is the input oriented CCR model (envelopment form) used in this study to estimate OTE. Note that the above mathematical program yields an efficiency score (θ) of a particular DMU_k only. To get the efficiency score of other DMUs it is required to repeat this process for each DMU i.e., 'n' optimization one for each DMU_j. DMUs for which $\theta < 1$ are inefficient, while DMUs for which $\theta = 1$ are on frontier line and efficient. Some frontier points or boundary points may be 'weekly efficient' because of presence of non zero slacks in inputs and/or outputs.

CCR efficient – a DMU is CCR efficient if the optimal solution of the above two-phase procedure satisfies both (i) $\theta = 1$ and (ii) all slacks are zero. So, DMUs which satisfy both the conditions are also called CCR efficient or strongly efficient or Pareto-Koopmans efficient.

CCR inefficient – a DMU is said to be CCR inefficient –

Case I: if and only if both (i) $\theta < 1$ (ii) $s_i^- \neq 0$, $s_r^+ \neq 0$ for some i and r. or all slacks are non zero.

Case II: if and only if both (i) $\theta = 1$ (ii) $s_i^- \neq 0$, $s_r^+ \neq 0$ for some i and r. This case is also termed as weakly efficient in DEA.

So there are two sources of inefficiencies: purely technical inefficiency represented by the radial measure (1- efficiency score obtained) and mix inefficiency represented by the input and output slack values.

BCC Model

The BCC (ratio) model is one of the most important extensions of CCR model. It measures technical efficiency rather pure technical efficiency. BCC model differs slightly yet remarkable from CCR model with an additional constraint.

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad (2)$$

in the above CCR envelopment model. This constraint is called convexity constraint in mathematics literature. It imposes of assessing the efficiency under VRS.

A DMU is BCC efficient if the optimal solution of the above two-phase procedure satisfies both (i) $\theta = 1$ and (ii) all slacks are zero. Otherwise, DMU is BCC inefficient.

Super-efficiency Model (SEM)

The study has also utilized input oriented super efficiency model under CRS assumption for ranking purpose as proposed by Andersen and Petersen[18] (1993). The basic DEA models – CCR & BCC maily distinguish the DMUs into two groups – efficient DMUs (having score equal to one) and inefficient ones (having score less than one). But it is not possible by these conventional models for ranking efficient DMUs since efficiency score of all the efficient DMUs are equal to one. To overcome this limitation, Andersen and Petersen (1993) have introduced super-efficiency DEA model. This model was originally introduced with the objective of providing tie breaking procedure for ranking DMUs rated as efficient in conventional DEA model. This model allows effective ranking of efficient DMUs based on super-efficiency scores which are more than one or equal to one i.e. not same for efficient DMUs.

The super-efficiency model is almost identical to the basic DEA models with the exception that the efficient DMU being evaluated is excluded from the production possibility set (PPS). This exclusion or removal from the PPS is the main philosophy of this models and forms a new frontier above such frontier and thereby allowing the efficiency score of the efficient DMUs grater than or at least equal to the value of 1(one). An important consideration of SEM is that this exclusion does not influence the efficiency score of inefficient DMUs. This is the specialty of this model. Like CCR and BCC models SEM are of two approaches – input oriented and output oriented both under CRS and VRS assumption.

In this study input oriented SEM under CRS assumption is followed for effective ranking of efficient DMUs as determined by input oriented CCR model.

The efficient frontier consisting line segment connecting efficient DMUs- A, B and C is developed by the standard DEA models. If DMU B is excluded from the reference set effect is to construct a new frontier consisting dotted line segment connecting DMUs A and C. Super-efficiency score of DMU B becomes $OB^{/} / OB \geq 100\%$. This reflects that the maximum proportional increase in inputs by B preserving efficiency (100%) is 20% if super efficiency score of B is 120%. Efficiency score of inefficient DMU like 'D' remains unchanged.

Input oriented SEM provides a means of evaluating the extent to which an efficient DMU is able to increase its inputs level without violating its status as an efficient DMU. Super-efficiency score therefore provides a measure of stability of the 'efficient' status of the efficient DMUs. The study follows the following input oriented formulation of SEM under CRS assumption as described by Andrson and Petersen (1993).

$$\underset{(\theta\lambda)}{\text{Min}}\ \theta_k - \mathcal{E}\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \qquad (3)$$

Subject to

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta_k x_{ik} \qquad i = 1,2,\ldots.,m.$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{rk} \qquad r = 1,2,\ldots.,s.$$

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

$$\lambda_k = 0$$

$$s_i^-, s_r^+ \geq 0 \text{ for all i and r.}$$

Where θ represents efficiency score of DMU 'k', an efficient one is excluded from the reference set by equating input and output weights to zero i.e.($\lambda_k = 0$)

7.3 APPLICATION OF DATA ENVELOPMENT ANALYSIS (DEA) TECHNIQUE

According to Berger and Humphrey (1997) at least five different efficiency techniques are commonly used by researchers. Simultaneously they also stated that there is no agreement on a preferred frontier model. They suggested that most efficiency studies were based on the Data Envelopment Analysis (DEA) technique. Hence this non-parametric test has been applied for the determination of relative efficiencies of the insurers.

Some of the salient pointscovered for efficiency analysisare as follows:

1. The efficiency analysis starts with defining the input and output variables.

2. Two main approaches may be adopted for efficiency measurement – (a) the Stochastic Frontier Approach (also known as "pertaining to chance" or the Econometric Approach), and (b) the Mathematical Approach.

3. The econometric approach has to make certain assumptions about the error term and also has to specify a functional form. As a result it enables discrimination between random changes and the company- specific non-random changes. The major drawback of this approachis that it causes two types of errors: (i) error in functional form specification and (ii) error relating to assumptions.

4. The mathematical programming approach is comparatively simpler approach as there is no requirement for assumptions regarding the random error term. So, the approach does not cover the effects of randomness. Eventually, it is not possible to discriminate between inefficiency due to company specific factors and those due to chance. So, this is a disadvantage of this method.

5. Data Envelopment Analysis (DEA) is one of the methods under the mathematical approach. It is non-parametric in nature as it does not make any assumptions about the population parameter. Thistechnique can be easily applied because it does not need priorifunctional specification ofthe unknown technology (Fukuyama, 1993; Favero and Papi, 1995).

6. DEA approach is used to develop a production frontier by which the efficiency of firms is estimated (Casu and Molyneux, 2003). This approach effectively estimates the frontier by finding a set of linear estimates that bound (envelop) the observed data (Leong et.al, 2003). This technique creates a convex- shaped frontier using which relative efficiency measurement is done.

7. DEA is a benchmarking technique in the sense that 'best practice' firms lie on the frontier and 'envelop' other inefficient firms (Neal, 2004). Therelative efficiency scores are determined for each unit by applying linear programming optimization technique. The term 'relative' means that it determines the efficiency of an unit with respect to the best-performing unit(s).

8. A firm is considered to be efficient in either of the two cases:

(a) If it cannot produce more outputs without increasing inputs, or

(b) If it cannot reduce its input without reducing its output.

9. The two basic models under the DEA technique have been applied in the initial part of the study. The first model was developed by Charnes, Cooper and Rhodes in 1978 which is known as CCR model.Then this model was modified in1984 by Banker, Charnes and Cooper and is known as BCC model. The difference in the two models is that CCR model considers Constant Returns to Scale (CRS) whereas BCC model considers Variable Returns to Scale (VRS). According to both these models, a DMU is efficient if the technical efficiency is equal to one. Under the CRS assumption, the efficiencies are known as technical or total technical efficiency(TE). Under the VRS assumptions, the efficiencies are known pure technical efficiency(PTE). A score of less than one implies inefficiency. PTE is sometimes known as controllable, managerial or X-inefficiency (Alexander and Jaforullah, 2005).

10. We know that the approach in DEA takes the form of either input-oriented or output-oriented model. The input oriented model compares the input used by an efficient firm to produce the same output. The output oriented model compares the output actually produced with the output produced by an efficient firm using the same input. In case there is inefficiency under input oriented model it implies that increasing the efficiency implies an equi-proportionate reduction in inputs to produce its output level as efficiently as the efficient units. On contrary, the output oriented modelsuggests equi-proportionate expansion of outputs, keeping the input unchanged so that the inefficient unit reaches the same level of efficiency as thetechnically efficient DMUs.

11. This approach finds out the best-practice firms against whom the efficiency level of other firms are determined. An efficientfirmmeans the one(s) which is (are) positioned on the frontier (or the best practice frontier). This term “best practice frontier” had been given by Farrell (1957). In certain cases there can be several firms which attain a relative score of one. A score of one would mean 100% relative efficiency level. The relatively inefficient firms will attain a score between zero and one. So, lesser the score higher is the inefficiency and vice-versa.

12. In this approach, the efficiency (or inefficiency) level is mapped by the firm’s distance from the frontier. More the distance, far is the position of the firm with respect to the ‘best practice’ firm, thereby indicating lower efficiency level. A point on the frontier indicates that either (a) it produces maximum output using the same input(i.e.output maximization) (Coelli, Rao and Battese, 2005) or (b) it uses minimum inputs to produce the same output level (i.e. input minimization).

13. Therefore, the efficiency aspect covers the measure of technical efficiency which can be derived based on the assumption of returns to scale i.e. constant or variable.The efficiency result will depend on orientation of the model – whether it is input- oriented (which seeks input minimization) or output-oriented (which seeks output maximization).

14. The efficiency score will determine whether (a) minimum inputs have been used to produce the outputs or (b) maximum outputs have been produced using the inputs.

15. In the next part, in order to understand whether non-optimumutilization of scale contributes to inefficiency, scale efficiency (SE) has been computed. For computation of this efficiency form, the methodology applied by Coelli et. al (1998) is applied. For measuring Scale Efficiency(SE), measurement of technical efficiency under assumptions of both CRS (also called total technical efficiency) and VRS (called pure technical efficiency) is a prori requirement.

16. The relationship between three factors may be stated as follows:

Total Technical Efficiency (under CCR model)

= Pure Technical Efficiency (under BCC model) XScale Efficiency.

The two components Pure Technical Efficiency and Scale Efficiency are mutually exclusive and non-additive in nature.

The technical efficiency score under CRS is known as the "global" technical efficiency score. If there is a difference in the technical efficiency score under CRS and VRS, it implies existence of scale inefficiency, since it attains a score of less than one under scale efficiency measurement.

17. The resultsobtained from scale efficiencies can be used to draw inferences about the operating scale. If the scale efficiency attains a value of one, it implies operation under Constant Returns to Scale. So, the DMU is operating at the minimum point of the cost curve. With respect to scale, it is thought to be operating at the Most Productive Scale Size (MPSS). Nevertheless if the outcome does not show operation at CRS, it indicates the ill-effect of non- optimum scale utilization. Therefore, it represents a case of either increasing returns to scale (IRS) or decreasing returns to scale (DRS).

18. The existence of IRS implies that the firm size is very small and it is operating at the sub-optimal level. So, it is advisable to reduce cost by increasing the size. On contrary, DRS spots out that the firm size is too large and the resources are over- optimally used. Thus, reduction in output will help out in cost reduction.

The DEA technique is a very researcher-friendly approach as it is easy to understand and handle. This technique helps to deal with multiple input & multiple output cases with ease. The results of efficiency analysis points out the position of a Decision Making Unit (DMU) with respect to the best-performing peer(s) in the industry and thus can be effectively used in strategic decision-making.

In the next chapter, we determine therelative efficiency level of the public and private sector players for the application of DEA technique. The sample consists of 18 life insurers (as at the end of 2007-08). The total population comprises ofLIC, the only public sector player and the remaining 23 private life insurers. The study is based on the output-oriented approach. So,the aimof this model is to maximize outputs using the same quantity of inputs. For the determination of efficiency scores, both CRS and VRS techniques have been used, which helped us to derive the scale efficiency (or inefficiency) result through the multiplicative relationship existing between the three factors as cited above.

7.4. Research Design

Based on the earlier section, the study has chosen certain input and output variables for efficiency analysis. The choice of these two is not arbitrary but based on the review of received literature consisting of variousforeign andIndian articles. For a better insight about the choice of input and output variables,various research articles were studied.

The table below depicts the different variables used by different researchers for efficiency analysis of the insurance industry.

Table 7.1:Input and Output Variables used in various Efficiency Studies onInsurance

Sl.No.	Author(s) and Year	Variables		Area ofwork
		Input(s)	Output(s)	
01.	Abidin andCabanda (2011)	Business and administration expenses, marketing expense	Premium income, net underwriting income and investment income	Non-Life
02.	Bawa andRuchita (2011)	Equity capital, labour expenses (includes commission, agents' fee, referral and other expenditure)	Net premium	Health
03.	Boonyasai et. al (2002)	Labour, capital,materials	Premium Income, Investment Income	Life
04.	Chaffai andQuertani (2002)	Labour, physical capital and financial capital	Total premiums earned	Life, Non- life
05.	Cummins et.al(2002)	Operating expenses, capital, office workers	Reserves, invested assets, claims paid	Life, Non- life
06.	Cummins et.al(2003)	Labour, business services, financial capital	Incurred benefits, addition to reserves	Life, Non- life
07.	Cummins et. al(1996)	Operating expenses, capital	Reserves, invested asset, claims paid	Insurance companies
08.	Cummins and Zi(1998)	Labour, financial capital and materials	Benefit payments, addition to reserves	Life
09.	Davutyan andKlumpes (2008)	Labour, business services, equity capital	Present value of losses invested, premiums, invested assets	Life, Non- life
10.	Deacon (2001)	Total operating expense, total capital, total technical reserves, total borrowings from creditors	Net premium, total investment income	General insurance

11.	Diacon, Starkey and O'Brien (2002)	Total operating expenses, commissions, capital, technical reserves, total borrowings	Net premium, total investment income	Non-life
12.	Donny andFecher (1997)	Labour	Net premiums	Life, Non- life
13.	Ennsfellner et al. (2004)	Net operating expenses, equity capital andtechnical provisions	Incurred benefits, changes in reserves, total invested assets	Health / Life
14.	Fukuyama(1997)	Asset value, number of workers and tied agents	Insurance reserves, loans	Life, Non- life
15.	Jenlin and Wen(2008)	Investment expenses and Underwriting expenses	Net investment income to total assets, Loss incurred to net premium	Non-Life
16.	Klumpes (2007)	Labour, business services, debt capital, equity capital	Premiums, investment income	Life, non-life
17.	Latif (2011)	Labour, operating expenses	Investment earnings	Non-LifeInsurance
18.	Mansor andRadom (2000)	Claims, commission, salaries, expenses, other costs	New policy sales, premium, policies in force	Life
19.	Qiu and Chen (	Labour, equity capital, operating expenses	Annuity payment and benefit of death, injury and medical treaytment, addition to reserve	Life
20.	Rai (1996)	Labour, Capital, Claims	Premium	Insurance firms
21.	Tone and Sahoo(2005)	Business services, labour, debt capital, equity capital	Real losses incurred (i.e claims settled)	Life
22.	Gamarra and Growitsch (2008)	Acquisition and administrative expenses, equity capital	Incurred benefits, addition to reserves, bonuses and rebates	Life
23.	Sinha (2006)	Operating expenses, commission expenses	Net premium income, numberof productslaunched	Life
24.	Wende et. al(2008)	Operating expenses, equity capital, debt capital	Claims incurred, total invested assets	Property- liability
25.	Yao et. al (2007)	Labour, capital, payment and benefits	Premium, investment income	Life, Non- life

Source: Compiled

The table reflects that various inputs and outputs were applied by the researchers especially in foreign countries. Most of these variables could not be adopted in this study. The major reason behind it is that the variable(s) didnot satisfy the basic stipulation of non-negativity of the input/output which is required for application of a linear programming problem. For instance investment income has been widely used by manyresearchers across the globe. In Indian context this variable could not be used as it is a negative figure for many insurers particularly during the years of bullish trend in the market. The Indian life insurance industry is at a early stage compared to the developed economies of the world. The investment income is a negative figure because the increase or decrease in the valuation also comes under the head “Income from Investments” in both Policyholders’ Account andShareholders’ Account. So, the commencement year of the sub-prime mortgage crisis or financial turmoil (i.e. 2007-08), most of the insurers reflected negative returns on investment. Hence, the investment income could not be applied. Many of the inputs and outputs used by foreign researchers could not be obtained in the IRDA Annual Reports because those figureswere not disclosed. So, those could not be considered for the study.Thus, the review of foreign articles along with the Indian articles gave the clue for choice of input and output variables, all of which satisfied the basic conditions of non-negativity and data availability.

Input and Output Variables Used

The choice of input and output variables revolves around some basic questions:

(i) Which variables are to be considered for the purpose of DEA application?

(ii) How many input and output variables are to be considered for the purpose of our study?

While finding the answer of the**first** question, i.e. the variables to be considered as inputs and outputs, two basic points were kept in mind:

(i) The data set should be non-negative for the outputs and strictly positive for theinputs (Sarkis & Weinrach, 2001), and

ii) There should be a significant positive relationship between the input and output variables (which can be verified from the correlation between the two variables).

The second questionis equally important becauseDEA is sensitive to variable(s) selection. It is mentioned inefficiency studies that as more variables are added, there is a chance that some inefficient DMUs may become efficient (Smith,1997). Hence, in order to retain the discriminatory power of the technique, a reasonable number of input and output variables are to be considered. As a solution to this problem, the following two thumb rules, given by Cooper et. al. (2007) obtained in an article by Bala and Kumar (2011), are taken into consideration:

- $n \geq p \times q$, where n is the number of DMUs, p is the number of inputs and qis the number of outputs
- $r = 3 (p+q)$, where r is the total number of observations.

In this study, the following inputs and outputs are considered after a thoroughreview ofliterature andconsideration ofthe rules:

Table 7.2:Inputs and Outputs

Input Variables	Output Variables
▪ Owner’s Equity ▪ Commission Expenses ▪ Operating Expenses	▪ Net Premium ▪ Benefits and Death Claims ▪ Assets under Management

Since the model uses three inputs and three outputs, we call it a three input-three output DEA model. Hence, the three inputs are Owner’s Equity (Eq), Commission Expenses (COME) and Operating Expenses(OE) whereas the three outputs are Net Premium Income(PI) , Benefits and Death Claims (DC) and Assets under Management(AUM).

<u>DEA Software: Estimation of Efficiency Scores</u>

We have used output oriented CCR, BCC and Super- efficiency model by using DEA software ‘DEA –Solver Learning Version 3’ design on the basis of the textbook “Date Envelopment Analysis : A Comprehensive text with models, application references and DEA- solver software”.

7.5 Technical Efficiency of Life Insurance Companies of India using Dynamic Panel Approach

The study uses window analysis developed by Klopp (1985) to compare the performance of the major life insurance companies operating in India using a two output two input framework. The window approach evaluates firms on the basis of a panel of observations and thus is different from the conventional DEA. In the conventional DEA, technical efficiency for any particular decision-making unit(DMU) is measured by evaluating the DMU in the light of all the DMUs under observation for the time period. The present study encompasses 18 life insurance companies for the period 2007-08 to 2012-13.The results available from the study suggest that there still exists a huge gap between the Life Insurance Corporation (LIC) of India and other life insurance companies in terms of technical efficiency. However, the gap is expected to come down in future with growing market share of the new entrants.

The performance of productive units is usually assessed in terms of technical efficiency.The concept of technical efficiency so often used in the efficiency/productivity relatedliterature, actually emerged from the writings of T.C. Koopmans and M.J. Farrell. Koopmans (1951), defined technical efficiency in the following manner: A producer isconsidered technically efficient if (a) an increase in any output requires—(i) a reduction inat least one other output or (ii) an increase in at least one input and if (b) a reduction in any input requires—(i) an increase in at least one other input or (ii) a reduction in at least one output. Because of its Paretian implication, this approach is known as the Pareto- Koopmans efficiency approach.

Farrell (1957) laid the foundation for new approaches to efficiency and productivity studies at the micro level, providing invaluable insights on two issues: defining efficiency and productivity, and the calculation of the benchmark technology and the efficiency measures. The core of the contribution of Farrell comprised the following:

(i) Introduction of efficiency measures based on radial uniform contractions orexpansions from inefficient observations to the frontier,

(ii) Specification of the production frontier as being the most pessimistic piecewiselinear envelopment of the data,

(iii) Construction of the frontier through solution of the systems of linear equations,

Obeying the two conditions on the unit isoquant:

(i) that its slope is not positive;

(ii) that no observed point lies between it and the origin.

The most immediate consequence of the Farrell measure of efficiency has been the decomposition of efficiency into technical efficiency, price (or allocative) efficiency and overall efficiency corresponding to a firm. The radial contraction/expansion connecting inefficient observed points with (unobserved) reference points on the production frontier as the basis for the measures is the hallmark, and due to fundamental duality between Production and cost functions identical measures can also be defined using the latter. Thus, the Farrell approach enabled us to identify at least three efficiency measures:

(a) Technical efficiency: inputs needed at best practice to produce observed outputsrelative to observed input quantities, maintaining observed input ratios;

(b) Price efficiency: costs of producing observed output at observed factor pricesassuming technical efficiency, relative to minimised costs at the frontier;

(c) Overall efficiency: costs of producing observed output if both technical efficiency andprice efficiency are assumed relative to observed costs.

Measurement of Technical Efficiency

In the production approach, measurement of technical efficiency requires constructionof production frontier. This is because efficiency is computed by measuring the distance of an observed point from an idealised production frontier. There are, however, two major competing paradigms for the construction of the frontiers: econometric and mathematical programming (DEA/FDH).

DEA Approach

Data envelopment analysis (DEA) is a non-parametric linear programming tool generally used for performance evaluation of economic units. The USP of the method is that it requires very few prior assumption on input-output relationship. The DEA method enables extension of the single input-single output technical efficiency measure to the multiple output-multiple input case. In its constant returns to scale form, the DEA methodology was developed by Charnes et al. (1978). Banker et al. (1984) extended the approach to the case of variable returns to scale. The DEA approach constructs the production frontier from piecewise linear stretches resulting in a convex production possibility set.

Estimation of Technical Efficiency in the Radial DEA Model

Let us consider a productive firm which produces a scalar output Y from a bundle of k inputs x=(x1, x2, …, xk). Let (xi, yi) be the observed input-output bundle of firm i (i=1,2, …n). The technology used by the firm is defined by the production possibility set.

PPS = {(x,y) : y can be produced from x }

An input-output combination (x0, y0) is feasible if and only if (x0, y0) ∈ Ps

In the input oriented approach (input minimisation subject to output constraint), the problem for any particular firm (under variable returns to scale) is:

Max φ

s.t. Y , , 1, 0

o 0 $\varphi \leq \lambda Y$ $X \geq \lambda X$ $\Sigma\lambda j = \lambda j \geq$

Technical efficiency = $1/\varphi$

Intertemporal DEA: The Window Analysis

In the conventional DEA technical efficiency for any particular decision-making unit.(DMU) is measured by evaluating the DMU in the light of all the DMUs under observationfor the time period. This process is repeated for subsequent periods. In the case of Window Analysis, the basic idea is to treat each DMU as a different DMU for different time periods. One thus forms a panel of observations out of the DMU specific observations for different years. The panel is moving in nature i.e., as we progress, the observations relating to the initial years are dropped and those of later years are included. Each DMU is evaluated for the panel years against the panel so formed. The USP of this approach is that one can carry out a kind of sensitivity analysis as to how the efficiency scores change when we migrate from one panel to another as well as to consider the trend in efficiency within the panels. In spite of its elegance, the method has not been used in the Indian context so far.

Empirical Efficiency Estimation of Life Insurance Companies

The study seeks to capture the inter-temporal efficiency trend of Indian life insurance companies for 2007-08 to 2012-13 using a two output-two input framework.Towards this end, the present study makes use of the Window approach developed by Klopp (1985).

Choice of Output/Input

Defining outputs of insurance firms is a challenging task. Most of the life insurance cost studies focussing on economies of scale and scope, used premiums as proxies for outputs (e.g., Grace and Timme, 1992 and Gardner and Grace, 1993). However, some argued that premiums are not the quantity of outputs but the revenue (price times quantity) (Doherty, 1981; Yuengert, 1993).

As such, the outputs of life insurers may be measured by the services they provide to customers. In general, life insurers provide two principal services: risk bearing/risk pooling services and intermediation services. Life insurers collect premiums and annuity considerations from customers and redistribute most of the funds to those policyholders who sustain losses (the risk bearing/risk pooling service). Funds are collected in advance of paying benefits and held in reserves until claims are paid (the intermediation service).

In view of this, the present paper considers two output indicators: operating income and net premium income=(gross premium earned-reinsurance ceded+reinsurance accepted).

We have included premium income as one of the output indicators because in the early years the growth of premium income facilitates the new entrants to consolidate their business.

On the other hand, operating income is indicative of the intermediation service rendered by the life insurer.

In this study, total expenses related to insurance business have been taken as the proxy for the inputs used by the life insurers. The production relation, therefore, is: output(operating income, net premium income)=f (operating expenses, commissions paid).

Estimates have been made for the six-year period: 2007-08 to 2012-2013.

Choice of Window Length

Suppose we have m number of DMUs with observations for n periods. Suppose also that k is the length of the window ($k \leq n$). Then the length of the window is determined on the basis of the formula:

$k=(n+1)/2$ when n is odd and $k=(n+1)/2 \pm 1/2$ when n is even.

For a detailed account on this, see Charnes and Cooper (1991).

In the present study n=6, so k=3.5. Thus, the window length has been taken as 3 for the estimation of technical efficiency.

In the later part, the three input three output model has been used for dynamic panel approach covering a period of nine years 2007-08 to 2015-16. As n=10, so k=5 has been considered in this study. The results are in the next chapter.