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## Abstract

This paper applies a new variant of data envelopment analysis model to examine the performance trend of Life Insurance Corporation (LIC) of India for the period covering before and after financial liberalization is introduced. This study finds that since the beginning of our study period, LIC's performance has been declining. More importantly, the declining performance trend particularly after 1994-95 can be taken as the evidence of increasing allocative inefficiencies arising from LIC's poor management including leadership, management style, and decisional capability. This finding is also evident from the substantial fall in the degree of scale economies from around 0.90 to around 0.70.

*Key Words*: LIC, DEA; Efficiency, Returns to Scale; Economies of Scale; Degree of Scale Economies.

# Cost Efficiency and Returns to Scale in Life Insurance Corporation of India Using Data Envelopment Analysis*

## 1. Introduction

Life Insurance Corporation (LIC) of India was formed in September in 1956 with a capital contribution of Rs.5 crores from Government of India. LIC is the only insurance company providing an insurance cover against various risks in life for the last 44 years. A monolith then, the corporation, enjoyed a monopoly status and became synonymous with life insurance. Among its various products, endowment assurance (participating) and money back (participating) are most popular, comprising 80% of the life insurance business. For the year 1998-99 LIC had Rs.75606.26 crores [1 crore = 10 million] in assurances and Rs. 13.08 crores in annuities. The number of policies in assurance is 148.57 lakhs and in annuities is 0.06 lakhs. The annual premium in assurance is Rs.4880.52 crores and in annuities Rs.4.93 crores. Insurance penetration in 1997 is 1.39% compared to 9.42% in Japan according to Swiss Reinsurance Company [31]. Insurance density in 1997 is $5.4 compared to $3092 in Japan. Even though LIC in India enjoyed monopoly status, the above figures raise questions on the efficiency/productivity status of LIC. We therefore study the LIC's performance over the past 17 years covering both prior and post financial liberalization.

In insurance sector, multiple outputs are produced using multiple inputs. These inputs and outputs are denominated in non-homogeneous units. Traditional single-factor (e.g., labor productivity or capital productivity) ratio may be used in these circumstances to produce a set of *ad hoc* productivity measures. Yet there is no reason *a priori* that these single-factor ratios should yield a consistent summary view of performance. A summary total-factor measure of performance avoids the ambiguity of single-factor ratios, but requires the aggregation of inputs and outputs. Data Envelopment Analysis (DEA) [4,12] embodies the principle of total-factor view of efficiency, and in addition, provides a

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system of weights allowing the reduction of multiple ratios into a scalar overall view of performance.

While the literature that addresses the returns to scale and efficiency is relatively abundant, the research on using DEA/frontier production method to evaluate this productive performance in insurance sector is quite sparse and fairly recent. The recent applications of DEA models on insurance sector include works on the efficiency of organizational forms and distribution systems of the US property and liability insurance industry by Brocket *et al.* [10] and Cummins *et al.* [15]. However, the application of DEA on Indian insurance sector in India is nil. Financial liberalization in Indian economy started in 1991. Malhotra [22] finds that LIC is a monolith and recommended liberalization in insurance. Banerjee [1] found that effectiveness of insurance penetration and insurance density was low. The recent passage of the Insurance Regulatory and Development Authority (IRDA) Bill, 2000 along with expected amendments to the LIC and GIC Acts paves the way for the entry of private players, and possibly the privatization of the hitherto public monopolies LIC and GIC. See also the study of Ranade and Ahuja [24] for detailed discussion on various issues in regulation of insurance. Since life insurance is as much about savings as about protection, it would increasingly compete with banks and mutual funds for people's savings. Recently, the Reserve Bank of India issued guidelines [26] for banks, which wish to enter into insurance business in India. In the light of above-mentioned studies, the current paper, using DEA, aims at evaluating LIC's performance (in terms of cost efficiency and returns to scale) in this competitive environment. The study uses the aggregate time-series data on Indian life insurance sector from 1982-83 to 1998-99 for the aforementioned purpose.

The structure of the paper is as follows: Section 2 discusses a new variant of DEA model for production and cost analyses in the light of shortcomings existing in the old cost DEA model, and describes the relationship among DEA results, underlying efficiency concepts, scale economies, and returns to scale from the perspective of new production and cost performance. The data set regarding LIC operations is discussed in Section 3. Section 4 deals with results and discussion, and Section 5 ends with concluding remarks.

## 2. DEA models

In this section we deal with $n$ DMUs, each using $m$ inputs of $x = (x_1, x_2,\ldots,x_m)$ to produce $s$ outputs of $y = (y_1, y_2,\ldots,y_s)$. For a $DMU_0$ ($0 = 1,2,\ldots,n$), let the inputs and outputs be $x_0 = (x_{10}, x_{20},\ldots x_{m0})$ and $y_0 = (y_{10}, y_{20},\ldots,y_{s0})$ respectively, and the unit cost of inputs $x_0$ be $c_0 = (c_{10}, c_{20},\ldots,c_{m0})$.

Tone [39] has recently shown that if any two DMUs (A and B, say) have the same amount of inputs and outputs, i.e., $x_A = x_B$ and $y_A = y_B$ and the unit cost of for DMU A is twice that of DMU B for each input, i.e., $c_A = 2c_B$, then both the DMUs exhibit the same overall and allocative efficiencies. This finding is termed as 'strange' because they have achieved the same efficiencies irrespective of their differed cost structures[1]. This strange case arises due to the supposed production possibility set $P$ as defined by:

$$P = \{(x, y) : x \geq X\lambda, y \leq Y\lambda, \lambda \geq 0\} \qquad \ldots\ldots\ldots(1)$$

$P$ is defined only by using technical factors $X = (x_1, x_2,\ldots,x_n) \in R^{m \times n}$ and $Y = (y_1, y_2,\ldots,y_n) \in R^{s \times n}$, but has no concern with the unit input cost $C = (c_1, c_2,\ldots,c_n)$. In the light of above problem he suggested the following cost-based production possibility set $P_c$:

$$P_c = \left\{\left(\bar{x}, y\right) : \bar{x} \geq \bar{X}\lambda, y \leq Y\lambda, \lambda \geq 0\right\} \qquad \ldots\ldots\ldots(2)$$

where $\bar{X} = (\bar{x}_1, \bar{x}_2,\ldots,\bar{x}_n)$ with $\bar{x}_j = (c_{1j}x_{1j}, c_{2j}x_{2j},\ldots,c_{mj}x_{mj})^T$.

Based on this new production possibility set $P_c$, a *new technical and scale efficiency* [NTSE ($\bar{\theta}^*$)] is obtained as the optimal solution of the following LP problem:

[1] See Appendix B for the detailed explanation.

$$[NTech_{crs}] \quad \bar{\theta}^* = \min \bar{\theta} \qquad \text{..........(3)}$$
$$\text{subject to} \quad \bar{\theta}\bar{x}_0 \geq \bar{X}\lambda$$
$$y_0 \leq Y\lambda$$
$$\lambda \geq 0.$$

Similarly, *new technical efficiency* of $DMU_0$ is computed from the [$NTech_{vrs}$] model, which is obtained by imposing a convexity constraint ($e\lambda = 1$) in [$NTech_{crs}$] where $e \in R^n$ is a row vector with each of its elements being equal to one.

The *new overall and scale efficiency* [NOSE ($\bar{\gamma}^*$)] is defined as $\bar{\gamma}^* = e\bar{x}_0^* / e\bar{x}_0$, and $\bar{x}_0^*$ is the optimal solution of the LP given below:

$$[NCost_{crs}] \quad \min e\bar{x} \qquad \text{..........(4)}$$
$$\text{subject to} \quad \bar{x} \geq \bar{X}\lambda$$
$$y_0 \leq Y\lambda$$
$$\lambda \geq 0.$$

The *new allocative and scale* efficiency [(NASE ($\bar{\alpha}^*$)] is then defined as the ratio of $\bar{\gamma}^*$ to $\bar{\theta}^*$, i.e., NASE ($\bar{\alpha}^*$) = NOSE ($\bar{\gamma}^*$)/NTSE ($\bar{\theta}^*$). Similarly, the [$NCost_{vrs}$] model can be introduced by adding a convexity constraint ($e\lambda = 1$) in [$NCost_{crs}$] where the *new allocative efficiency* is obtained as the ratio of the *new overall efficiency* to *new technical efficiency*. It is to be noted here that the NOSE is not greater than NTSE, and these new efficiency measures are all units invariant [39].

The dual of the [$NCost_{vrs}$] model can be represented by the following LP problem:

$$[NCost_{vrs}] \quad \max \sum_{r=1}^{s} u_r y_{r0} + \sigma_1 - \sigma_2 \qquad \text{..........(5)}$$
$$\text{subject to} \quad -\sum_{i=1}^{m} v_i \bar{x}_{ij} + \sum_{r=1}^{s} u_r y_{rj} + \sigma_1 - \sigma_2 \leq 0, \quad (\forall j)$$
$$v_i = 1, \quad (\forall i)$$
$$u_r \geq 0, \quad (\forall r)$$
$$\sigma_1 \geq 0, \quad \sigma_2 \geq 0.$$

The primal and dual of $[NCost_{vrs}]$ can be considered respectively as special forms of Assurance Region (AR) DEA model of Thompson *et al.* [34,35] and Cone Ratio (CR) model of Charnes *et al.* [11,13], where the availability of the reasonable price vectors enters as input weight in the general DEA model. See also Schaffnit *et al.* [28] for further discussion.

Following Sueyoshi [32], we redefine the ratio $\omega^* = (\sigma_1^* - \sigma_2^*)/[NCost_{vrs}]$ (where * represents optimal value) and characterize the various measures of scale efficiency, e.g.,

Increasing returns to scale (IRTS) if and only if $\sigma_1^* > 0$ and $0 < \omega^* < 1$,
Constant returns to scale (CRTS) if and only if $\sigma_1^* = \sigma_2^* = 0$ and $\omega^* = 0$,
Decreasing returns to scale (DRTS) if and only if $\sigma_2^* > 0$ and $\omega^* < 0$.

Following Baumol *et al.* [6] and Sueyoshi [32], we define the new degree of scale economies (NDSE) at $(c_0 = e, y_0)$ as

$$DSE_0 = [NCost_{vrs}]/\left(\sum_{r=1}^{s} u_r^* . y_{r0}\right) = [NCost_{vrs}]/u^* y_0 \qquad \text{..........(6)}$$

and show the equivalence of IRTS with $DSE_0 > 1$, CRST with $DSE_0 = 1$ and DRTS with $DSK_0 < 1$.

The new degree of scale economies cannot be uniquely determined at $(c_0 = e, y_0)$ only when there is problem of degeneracy, i.e. there are multiple supporting hyperplanes. The upper and lower bounds of $\omega$ then need to be identified from the following LP model:

$$\begin{aligned} &\text{max/min} \quad \sigma_1 - \sigma_2 \qquad \text{..........(7)} \\ &\text{subject to} \quad -\sum_{i=1}^{m} v_i \bar{x}_{ij} + \sum_{r=1}^{s} u_r y_{rj} + \sigma_1 - \sigma_2 \le 0, \quad (\forall j) \\ &v_i = 1, \quad (\forall i) \\ &\sum_{r=1}^{s} u_r y_{r0} = [NCost_{vrs}], \\ &u_r \ge 0, \quad (\forall r) \\ &\sigma_1 \ge 0, \quad \sigma_2 \ge 0. \end{aligned}$$

The upper and lower bounds of $\omega$ are respectively obtained from max $(\sigma_1^* - \sigma_2^*)$ and min $(\sigma_1^* - \sigma_2^*)$.

For the unique determination of returns to scale in production based DEA models, the problem of degeneracy is discussed extensively in Banker and Thrall [5], Banker *et al.* [2,3] and Tone [36].

It is to be noted here that in the above production-cost relationship it has been maintained that if production technology exhibits IRTS, then the cost function exhibits declining average cost curve, i.e. economies of scale operate. See the study of Sueyoshi [32,33] for the theoretical dual relationship between production-based and cost-based returns to scale. However, cost of production is a more general concept to include those savings in cost arising from sources like bulk buying at preferential lower prices, lower transport cost, lower advertising cost and other selling cost, etc., all of which have nothing to do with the production unit. Cost savings of this kind, if they exist, would also reduce the overall average cost as output expands, and they should be recognized as scale effects. Thus, these two concepts, returns to scale and economies of scale, have distinctive causative factors that do not permit them to be used interchangeably. A description concerning the conceptual differences between these two concepts lies beyond the scope of this study. However, the interested readers can refer to our earlier studies, e.g., Sahoo *et al.* [27] and Tone and Sahoo [40] in which both the concepts are critically analyzed and distinguished in the light of classical and neoclassical perspectives.

## 3. The data set regarding LIC operations

A modified version of the value added approach to measure life insurance output is adopted in our study. The value added approach counts as important outputs those that are significant value added, as judged using operating cost allocations [8]. We follow the recent insurance efficiency literature in defining insurance output as the present value of real losses incurred [e.g., 7,15]. We have taken losses as the claims settled during the year including claims written back ($y_1$). The rationale for the use of losses to proxy for insurance output is that the primary function of insurance is risk pooling, i.e. the collection of funds from the policyholder pool and the redistribution of funds to those pool members who incur losses [15]. Losses are deflated to the base 1995 using the Consumer Price Index (CPI). The CPI data are taken from *International Financial Statistics Year Book* [19].

Following the study of Brockett *et al.* [10], the ratio of liquid assets to liabilities ($y_2$) is taken as the second output in our study. Liquid assets have been taken as the sum of outstanding Premiums, Interest, Dividends, and rents outstanding; interest, dividends and rents accruing but not due; deposits with banks; cash and bank balance and remittances in transit. Liabilities are the probable future sacrifices of economic benefits stemming from present legal, equitable, or constructive obligations to transfer assets or to provide services to other entities in the future as a result of past events affecting the corporation. This ratio reflects a company's claims-paying ability; this is an important objective of an insurer firm, with improvement in claims-paying ability contributing to the likelihood of attracting and retaining customers.

Insurance inputs can be classified into four groups: business services ($x_1$), labor ($x_2$), debt capital ($x_3$) and equity capital ($x_4$). The business service is taken as commission to agents, which is material input, which is deflated by CPI. The input price index for business services ($c_1$) is calculated by dividing total deflated commission to agents with total active agents. The labor variable is taken as the total number of employees. The price per unit of labor ($c_2$) is calculated by dividing total deflated salary and other benefits to employees with total employees.

The debt capital of insurers consists of funds borrowed from policyholders. These funds are measured in real terms as the life insurance fund deflated using CPI. The cost of the policyholder supplied debt capital ($c_3$) is the rate of interest realized on the mean life insurance fund. Equity capital is an input for the risk-pooling function because it provides assurance that the company can pay claims even if there are larger than expected losses. The equity capital has been taken as sum of shareholders' paid up capital; general reserve; reserve for bad and doubtful debts, loans; reserve for house property and investment reserve. This value of equity capital deflated by CPI is considered an input category. Following the study of Gutfinger and Meyers [18], the cost of equity capital ($c_4$) is taken as 9% + rate of inflation. To summarize we use four inputs: business services, labor, policyholder-supplied debt capital, and equity capital. The data set related to LIC operations in 17 annual periods, are summarized in Table 1.

**Table 1: LIC Data on Inputs, Outputs and Inputs Prices**

| DMU | x1 | c1 | x2 | c2 | x3 | c3 | x4 | c4 | y1 | y2 | $\sum c_i x_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982/83 | 2.893 | 0.000023478 | 58595 | 0.000057550 | 243.147 | 0.0881 | 2.444 | 0.206 | 12.248 | 0.050 | 25.297 |
| 1983/84 | 2.655 | 0.000019969 | 60440 | 0.000067178 | 254.555 | 0.0919 | 2.318 | 0.175 | 13.221 | 0.051 | 27.860 |
| 1984/85 | 2.889 | 0.000019547 | 62977 | 0.000085656 | 275.643 | 0.0946 | 2.274 | 0.145 | 15.731 | 0.060 | 31.800 |
| 1985/86 | 3.332 | 0.000019312 | 66476 | 0.000083894 | 286.560 | 0.0987 | 2.141 | 0.179 | 16.489 | 0.051 | 34.244 |
| 1986/87 | 3.729 | 0.000018765 | 70207 | 0.000083699 | 302.129 | 0.1030 | 2.008 | 0.176 | 17.317 | 0.053 | 37.349 |
| 1987/88 | 4.524 | 0.000018861 | 72619 | 0.000081843 | 316.195 | 0.1050 | 4.218 | 0.186 | 18.913 | 0.059 | 39.928 |
| 1988/89 | 5.868 | 0.000019775 | 73283 | 0.000101529 | 350.695 | 0.1095 | 4.040 | 0.151 | 21.450 | 0.063 | 46.452 |
| 1989/90 | 7.087 | 0.000020345 | 88243 | 0.000089911 | 386.050 | 0.1113 | 3.800 | 0.180 | 23.508 | 0.076 | 51.586 |
| 1990/91 | 7.854 | 0.000018933 | 96289 | 0.000086409 | 410.419 | 0.1144 | 3.406 | 0.228 | 25.302 | 0.079 | 56.049 |
| 1991/92 | 8.509 | 0.000018319 | 104918 | 0.000082187 | 448.209 | 0.1195 | 3.187 | 0.208 | 27.733 | 0.080 | 62.847 |
| 1992/93 | 9.388 | 0.000018937 | 114927 | 0.000084563 | 498.157 | 0.1156 | 3.121 | 0.153 | 33.114 | 0.072 | 67.783 |
| 1993/94 | 10.318 | 0.000019674 | 123785 | 0.000079317 | 547.583 | 0.1243 | 3.098 | 0.192 | 36.980 | 0.070 | 78.478 |
| 1994/95 | 10.642 | 0.000020486 | 121410 | 0.000088333 | 599.789 | 0.1221 | 2.866 | 0.193 | 40.761 | 0.075 | 84.512 |
| 1995/96 | 11.019 | 0.000021442 | 125736 | 0.000101879 | 667.707 | 0.1229 | 4.472 | 0.180 | 41.580 | 0.075 | 95.676 |
| 1996/97 | 12.418 | 0.000023293 | 126620 | 0.000110113 | 751.369 | 0.1239 | 4.017 | 0.162 | 48.729 | 0.072 | 107.688 |
| 1997/98 | 12.909 | 0.000023113 | 125619 | 0.000104098 | 800.551 | 0.1237 | 4.467 | 0.222 | 50.507 | 0.079 | 113.097 |
| 1998/99 | 14.666 | 0.000024517 | 124385 | 0.000121662 | 933.253 | 0.1196 | 4.770 | 0.123 | 55.554 | 0.069 | 127.337 |

**Sample selection**

Our primary data source is the annual statements of Life Insurance Corporation of India (LIC) for the period from 1982-83 to 1998-99. LIC is the only state owned insurance, which has been in operation in India since 1956. See Appendix A for a brief description on Indian LIC. Though LIC has several branches all over India, the relevant data are not available for each of these branches. The annual statement of LIC is the only database, which compiles the aggregate figures of necessary operational and financial data of all its braches. Following the earlier studies of Boussofiane *et al.* [9], Ray and Kim [25] and Sueyoshi [32,33], we have therefore treated each year's operation of LIC as a distinct decision making unit (DMU). Liberalization of the Indian Financial Sector started in the year 1991. We have taken the data for 17 years (treating them 17 DMUs) covering before and after the liberalization so that the any effect of opening of the economy on the monopoly status of LIC could be carefully studied.

## 4. Result and discussion

The analysis of efficiency on the input-side rather than the output-side is becoming common in DEA applications for a variety of reasons. First, real world managers are never given a bundle of inputs and told to produce the maximum output from it. Instead they are given output targets and told to produce it most efficiently, i.e., with minimum inputs. Second, profitability in any business hinges on the efficiency of operations. But if the business involves a commodity, then what depends on efficient operations is survival. When prices are beyond a company's control, what remain are costs on inputs. This reflects the companies' emphasis on the input dimensions of policies. On a tentative basis, it has been suggested in the literature that costs (or inputs) are generally more predictable than outputs, giving cost targets a greater credibility than those for outputs [29]. Sengupta [29] has argued that: "..... data variations may arise in practical situations ...... when the output measures have large and uncertain measurement errors which are much more significant than in the input measures (p. 2,290). For example in school efficiency studies, the input costs, such as teachers' salaries, administrative expenses, etc., may have low measurement errors whereas the performance test scores of students may contain large errors of measurement of true student quality". This argument is most compelling where measurement errors are large relative to true random fluctuations in the production process.

We have listed down here the following notations used in our study.

| | |
|---|---|
| **TSE** | : Technical and scale efficiency, the CCR solution for the original data set $(X, Y)$. |
| **AR** | : Assurance region efficiency under CRTS assumption for original data set $(X, Y)$. |
| **S-SBM** | : Super Slacks –based measure of efficiency for $(X, Y)$. |
| **NTSE** | : Technical and scale efficiency, the CCR solution for the cost-based data $(\bar{X}, Y)$ set $(\bar{X}, Y)$. |

**NOSE** : Overall and scale efficiency, the cost efficiency for $(\bar{X},Y)$ under the assumption of CRTS.

**NASE** : Allocative and scale efficiency for $(\bar{X},Y)$ under CRTS assumption.

**NS-SBM** : Super slacks-based measure of efficiency for $(\bar{X},Y)$.

**NDSE** : Degree of scale economies for $(\bar{X},Y)$.

The efficiency estimates are calculated using the assumption of CRTS for the reference technology. As pointed out Färe *et al.* [16], this technology has some useful features in that it captures the notion of maximal average product (consistent with the minimum point on a long-run U-shaped average cost curve), which provides a very nice benchmark for identifying the optimal scale. The various efficiency scores are reported in Table 2.

**Table 2: Various Efficiency Scores**
(Four Inputs and Two Outputs)

| Year | TSE | S-SBM | AR | NTSE | NOSE | NASE | NS-SBM |
|---|---|---|---|---|---|---|---|
| 1982/83 | 0.945 | 0.862 | 0.937 | 1.000 | 1.000 | 1.000 | 1.063 |
| 1983/84 | 0.925 | 0.891 | 0.915 | 1.000 | 0.963 | 0.963 | 1.017 |
| 1984/85 | 1.000 | 1.129 | 1.000 | 1.000 | 1.000 | 1.000 | 1.156 |
| 1985/86 | 0.991 | 0.967 | 0.934 | 0.980 | 0.973 | 0.994 | 0.950 |
| 1986/87 | 1.000 | 1.001 | 0.929 | 0.967 | 0.937 | 0.969 | 0.957 |
| 1987/88 | 0.984 | 0.838 | 0.969 | 0.978 | 0.958 | 0.979 | 0.838 |
| 1988/89 | 1.000 | 1.008 | 0.992 | 0.939 | 0.933 | 0.994 | 0.819 |
| 1989/90 | 1.000 | 1.002 | 1.000 | 0.929 | 0.921 | 0.991 | 0.798 |
| 1990/91 | 1.000 | 1.003 | 1.000 | 0.923 | 0.913 | 0.988 | 0.798 |
| 1991/92 | 0.996 | 0.916 | 0.985 | 0.922 | 0.892 | 0.968 | 0.848 |
| 1992/93 | 1.000 | 1.001 | 0.993 | 1.000 | 0.988 | 0.988 | 1.012 |
| 1993/94 | 0.997 | 0.922 | 0.985 | 0.991 | 0.953 | 0.962 | 0.949 |
| 1994/95 | 1.000 | 1.077 | 1.000 | 1.000 | 0.975 | 0.975 | 1.037 |
| 1995/96 | 0.951 | 0.885 | 0.926 | 0.897 | 0.879 | 0.979 | 0.852 |
| 1996/97 | 1.000 | 1.008 | 0.982 | 0.965 | 0.915 | 0.947 | 0.946 |
| 1997/98 | 1.000 | 1.011 | 0.965 | 1.000 | 0.903 | 0.903 | 1.004 |
| 1998/99 | 1.000 | 1.033 | 0.930 | 1.000 | 0.882 | 0.882 | 1.069 |

It is seen from Table 2 that the technical and scale efficiency scores do not exhibit any trend, and most of these scores tend towards 1. In order to differentiate the efficient units, we have reported super slack-based measure (S-SBM) efficiency scores [14,37,38]. Since input price data are available, we have used assurance region model to calculate AR efficiency score where weight ratios, $(v_i/v_j)$, bounded between min $(c_i/c_j)$ and max $(c_i/c_j)$ for all $i < j$, are as follows:

**min** $(c_i/c_j)$ $(v_i/v_j)$ **max** $(c_i/c_j)$

$0.194772 \le v_1/v_2 \le 0.407958$
$0.000153 \le v_1/v_3 \le 0.000266$
$0.000083 \le v_1/v_4 \le 0.000199$
$0.000638 \le v_2/v_3 \le 0.001017$
$0.000279 \le v_2/v_4 \le 0.000989$
$0.427670 \le v_3/v_4 \le 0.972358$

The use of this AR model serves two purposes, one being that in compensating the degree of freedom problem (because our data are for 17 years only) and the other being from protecting the frequently occurring of zero weights for some of the important inputs. We see here that the trend of AR score is of rise and fall. However, there is a declining trend for the last three years of our study.

Now we turn to the new efficiency scores obtained from the cost-based production technology, which exhibit more rationality as is seen in Appendix B. Here we observe some trend in the new efficiency scores. Contrary to TSE score, LIC is said to operate efficiently for the first three years of our study (NTSE = 1), then exhibits declining performance up to 1991-92, i.e., the period of financial liberalization, after which the trend is of rise and fall in nature. However, the trend is of upward in nature from 1995-96. Coming back to our new overall and scale efficiency score trend, the fall in NOSE scores from 1984-85 to 1991-92 can be attributed mostly due to the fall in NTSE. However, for the last three years the declining trend of NOSE is mostly due to allocative inefficiency.

We feel here that the use of time series data for one firm over 17 years, and retaining a technology specification with two outputs and four inputs might lead to some objections from a methodological viewpoint. The small number of observations and the detailed specification of the technology can lead to some dimensionality problems. High dimensionality generates statistical problems in the convergence of DEA estimators [20] and in model misspecification [23]. With only 17 observations, the pertinence of an analysis in a 6-dimensional space might be questionable. For example, the lack of possible comparisons may explain most of the NTSE scores being one. It is also highlighted by quasi-systematic zero shadow prices of the second output in some of these years (which are not shown in table). We therefore decided not consider the second output i.e., the ratio of liquid assets to liabilities for two reasons, one being that it is a ratio whereas our first output is in absolute term, and the other being that there is a little variation in this ratio across years indicating constant company's claims-paying ability.

### 4.1 Production-based analysis

The production based DEA models are then rerun with four inputs and one output, and the resulting efficiency scores are reported in Table 3 (also see Figure 1).

We now observe the impact of not considering our second output variable, which has enhanced the discriminating power of DEA model. A closer look at the TSE column reveals that first, four efficient units now turn out to be inefficient and second, efficiency scores are relatively low. However the TSE trend is more or less the same as compared to its earlier trend. On the contrary, the AR scores reveal two clear trends, i.e. there is an upward trend up to 1994-95 followed then by a declining trend. However, the trend remains more or less the same in case of our NTSE scores as compared to its earlier one. Let us now turn to our cost-based efficiency scores.

**Table 3: Production-based Efficiency Scores (Four Inputs and One Output)**

| Year | TSE | S-SBM | AR | NTSE | NS-SBM |
|---|---|---|---|---|---|
| 1982/83 | 0.851 | 0.730 | 0.722 | 1.000 | 1.004 |
| 1983/84 | 0.915 | 0.856 | 0.747 | 1.000 | 1.014 |
| 1984/85 | 1.000 | 1.026 | 0.825 | 1.000 | 1.048 |
| 1985/86 | 0.991 | 0.967 | 0.831 | 0.980 | 0.950 |
| 1986/87 | 0.994 | 0.949 | 0.828 | 0.967 | 0.957 |
| 1987/88 | 0.952 | 0.784 | 0.860 | 0.978 | 0.837 |
| 1988/89 | 0.921 | 0.768 | 0.891 | 0.939 | 0.808 |
| 1989/90 | 0.896 | 0.747 | 0.879 | 0.929 | 0.775 |
| 1990/91 | 0.907 | 0.763 | 0.888 | 0.923 | 0.780 |
| 1991/92 | 0.910 | 0.790 | 0.893 | 0.909 | 0.824 |
| 1992/93 | 0.978 | 0.876 | 0.962 | 1.000 | 1.006 |
| 1993/94 | 0.994 | 0.915 | 0.980 | 0.989 | 0.946 |
| 1994/95 | 1.000 | 1.054 | 1.000 | 1.000 | 1.037 |
| 1995/96 | 0.951 | 0.885 | 0.926 | 0.897 | 0.852 |
| 1996/97 | 1.000 | 1.008 | 0.982 | 0.965 | 0.946 |
| 1997/98 | 1.000 | 1.002 | 0.965 | 1.000 | 1.004 |
| 1998/99 | 1.000 | 1.033 | 0.930 | 1.000 | 1.069 |

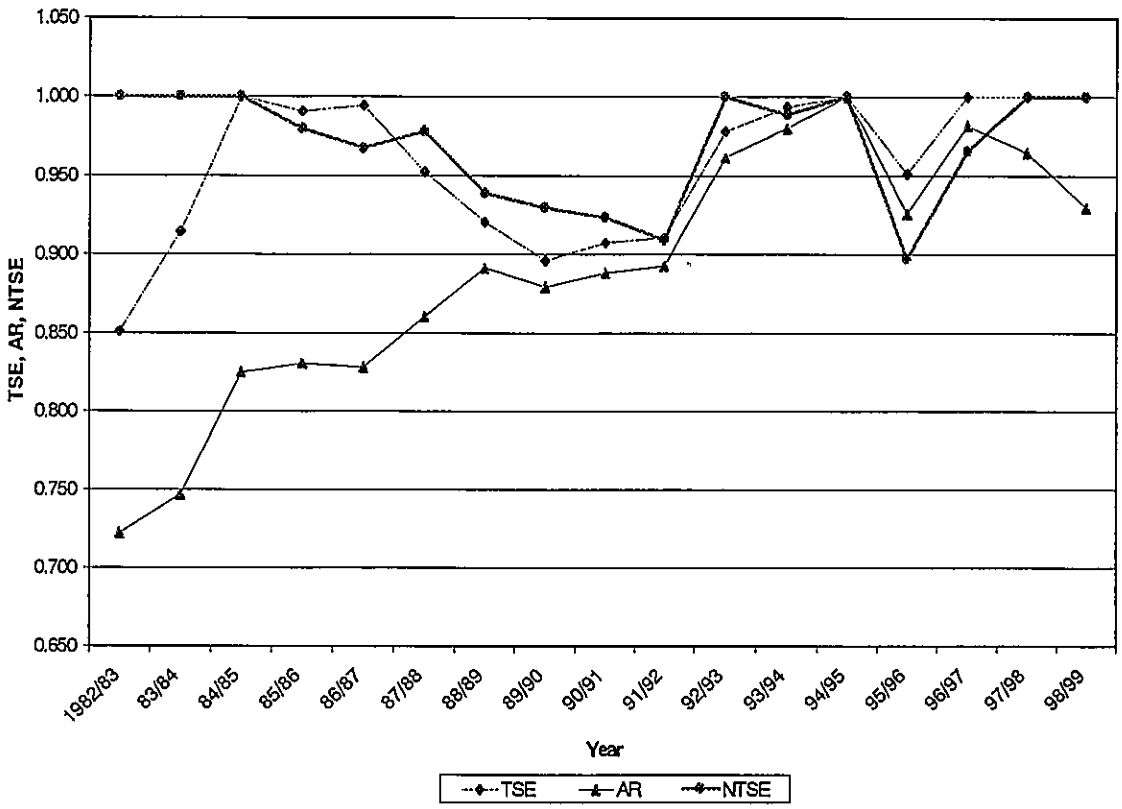


Figure 1: TSE, AR and NTSE Over Time

The improvement of technical efficiency particularly after 1994-95 can be claimed to arise either because of exposure of LIC to market competition arising from deregulation or because of changes in management and organizational structure. Leibenstein [21] maintains that the theoretical basis for claims that exposure to competition will generate improvement in efficiency is the notion of X-efficiency (or technical efficiency). He argued that enterprises exposed to the bracing atmosphere of competition would respond by eliminating internal inefficiency and seeking out opportunities for innovation. He refers to the productivity gains arising from this process as improvement in X-efficiency. To Stigler [30], this X-efficiency gain is nothing but simply an increase in the intensity of labor or, equivalently, a reduction in on-the-job leisure. Ganley and Grahl [17] pointed out that where labor productivity has increased due to such competition, there is evidence of increased work intensity.

A closer look at our data set reveals that labor productivity shows a monotonously increasing trend confirming the above-mentioned claim of increased work intensity. Further, it is learnt that LIC has recently used information technology (IT), e.g., UnixWare 7 to link over 2,000 branches throughout India and to serve approximately 11.6 million customers. UnixWare 7 links LIC's local area networks, metro area networks, wide area networks, interactive voice response system, and other technologies. This allows each branch office to act as a stand-alone entity with mutual access to all transactions, information and computer support for all policyholders. This adds further support to our finding of LIC running efficiently (technically and scale).

### 4.2 Cost-based analysis

Since the cost-based efficiency scores in the old cost-DEA model seem to be misleading, we have decided not to report it. Rather we report here our new cost and new allocative efficiency scores in Table 4, whose plots are also seen in Figure 2.

**Table 4: Cost-based Efficiency Scores**
(Four Inputs and One Output)

| Year | NOSE | NASE |
|---|---|---|
| 1982/83 | 0.979 | 0.979 |
| 1983/84 | 0.959 | 0.959 |
| 1984/85 | 1.000 | 1.000 |
| 1985/86 | 0.973 | 0.994 |
| 1986/87 | 0.937 | 0.969 |
| 1987/88 | 0.958 | 0.979 |
| 1988/89 | 0.933 | 0.994 |
| 1989/90 | 0.921 | 0.991 |
| 1990/91 | 0.913 | 0.988 |
| 1991/92 | 0.892 | 0.981 |
| 1992/93 | 0.988 | 0.988 |
| 1993/94 | 0.953 | 0.963 |
| 1994/95 | 0.975 | 0.975 |
| 1995/96 | 0.879 | 0.979 |
| 1996/97 | 0.915 | 0.947 |
| 1997/98 | 0.903 | 0.903 |
| 1998/99 | 0.882 | 0.882 |

We see here that contrary to our AR trend, the NOSE trend is of decline up to 1991-92, and then abruptly rises in the year 1992-93 after which the trend is again of declining. The declining trend of NOSE score up to 1991-92 is mainly attributed to the fall in the

NTSE scores whereas the declining trend after 1992-93 is mainly due to fall in the new allocative efficiency over years.

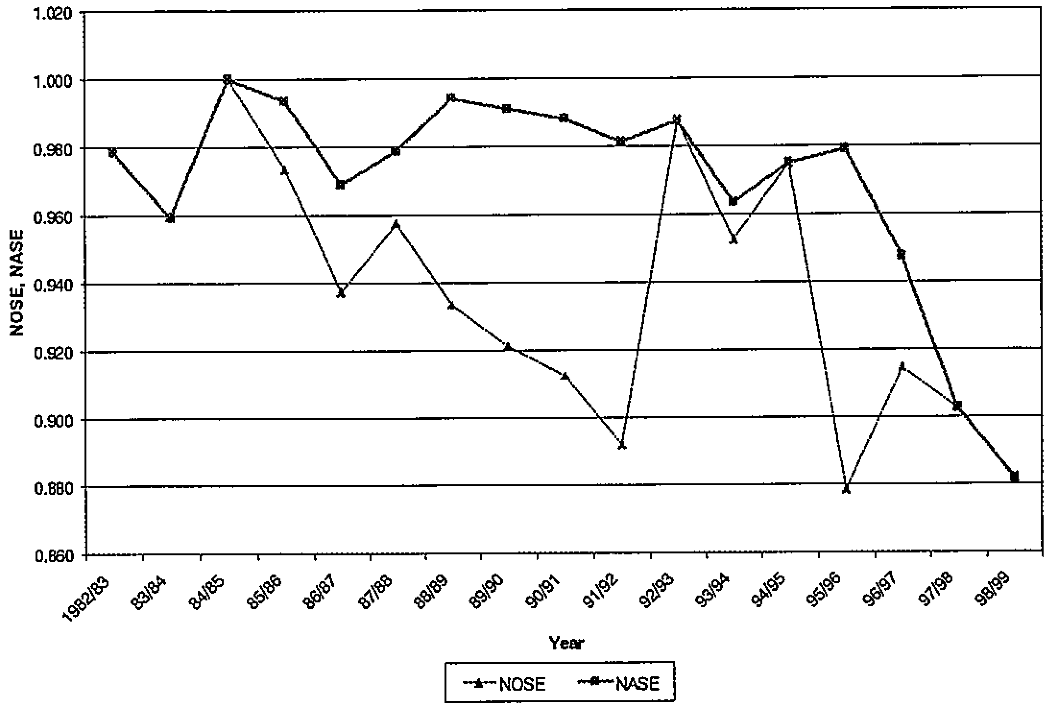


Figure 2: NOSE and NASE over Time

Financial liberalization in India started in 1991 and by the year 1995-96, the number of financial intermediaries had increased resulting intense competition of LIC with financial intermediaries. During this time period the policy pressures, which seemed to be revolving on LIC to behave less profligately, has acted on the one hand favorably for LIC, making it becoming more technically and scale efficient, but on the other hand, has resulted in decreasing allocative efficiency. We have already discussed possible explanations for improvement in X-efficiency (technical efficiency) in the last section. However, the declining trend of NASE reveals that the resource allocation is not proper, indicating the consumers are increasingly denying to accept what LIC is producing in the light of prevailing market prices. This reflects LIC's poor management including leadership, management style, and decisional capability in the proper allocation of its resources. There is a need for LIC management to bring about a change in its institutional and environmental variables so as to further improve its efficiency by reducing its allocative inefficiency for the time to come.

### 4.3 Returns to scale issue

Table 5 presents the estimated minimum cost, scale measures ($\sigma_1$ and $\sigma_2$), degree of scale economies (NDSE), and RTS in our new VRS cost model. We find here that LIC operates under increasing returns to scale (IRTS) for the first three years after which diminishing returns to scale (DRTS) sets in.

**Table 5: DSE and RTS**

| Year | [$Ncost_{vrs}$] | $\sigma_1$ | $\sigma_2$ | NDSE | RTS |
|---|---|---|---|---|---|
| 1982/83 | 25.297 | 2.429 | 0.000 | 1.106 | IRTS |
| 1983/84 | 27.114 | 2.429 | 0.000 | 1.098 | IRTS |
| 1984/85 | 31.800 | 2.429 | 0.000 | 1.083 | IRTS |
| 1985/86 | 33.369 | 0.000 | 0.764 | 0.978 | DRTS |
| 1986/87 | 35.083 | 0.000 | 0.764 | 0.979 | DRTS |
| 1987/88 | 38.387 | 0.000 | 0.764 | 0.980 | DRTS |
| 1988/89 | 43.638 | 0.000 | 0.764 | 0.983 | DRTS |
| 1989/90 | 47.899 | 0.000 | 0.764 | 0.984 | DRTS |
| 1990/91 | 51.612 | 0.000 | 0.764 | 0.985 | DRTS |
| 1991/92 | 56.644 | 0.000 | 0.764 | 0.987 | DRTS |
| 1992/93 | 67.783 | 0.000 | 0.764 | 0.989 | DRTS |
| 1993/94 | 76.241 | 0.000 | 4.658 | 0.942 | DRTS |
| 1994/95 | 84.512 | 0.000 | 4.658 | 0.948 | DRTS |
| 1995/96 | 86.883 | 0.000 | 33.489 | 0.722 | DRTS |
| 1996/97 | 107.579 | 0.000 | 33.489 | 0.763 | DRTS |
| 1997/98 | 112.726 | 0.000 | 33.489 | 0.771 | DRTS |
| 1998/99 | 127.337 | 0.000 | 33.489 | 0.792 | DRTS |

LIC's operation over 17 years can be divided into three in order to see the impact of financial liberalization. 1982-83 - 1984-85, 1985-86 – 1994-95 and 1995-96 – 1998-99. See Figure 3 where NDSE scores are plotted over time. In the beginning three years of our study, LIC operates under IRTS whose DSE (IRTS) trend is more or less constant, followed by constant DSE (DRTS) trend for the middle period. However, the competition in the insurance sector, particularly after 1994-95 has further aggravated the poor performance of LIC as is seen from the steep fall of NDSE score from 0.90 + to 0.70 + for the last three years of our study. However, the NDSE (DRTS) trend is upward indicating the importance level of LIC's scale expansion to show a sign of recovery, which can be thought of possible due to such competition.

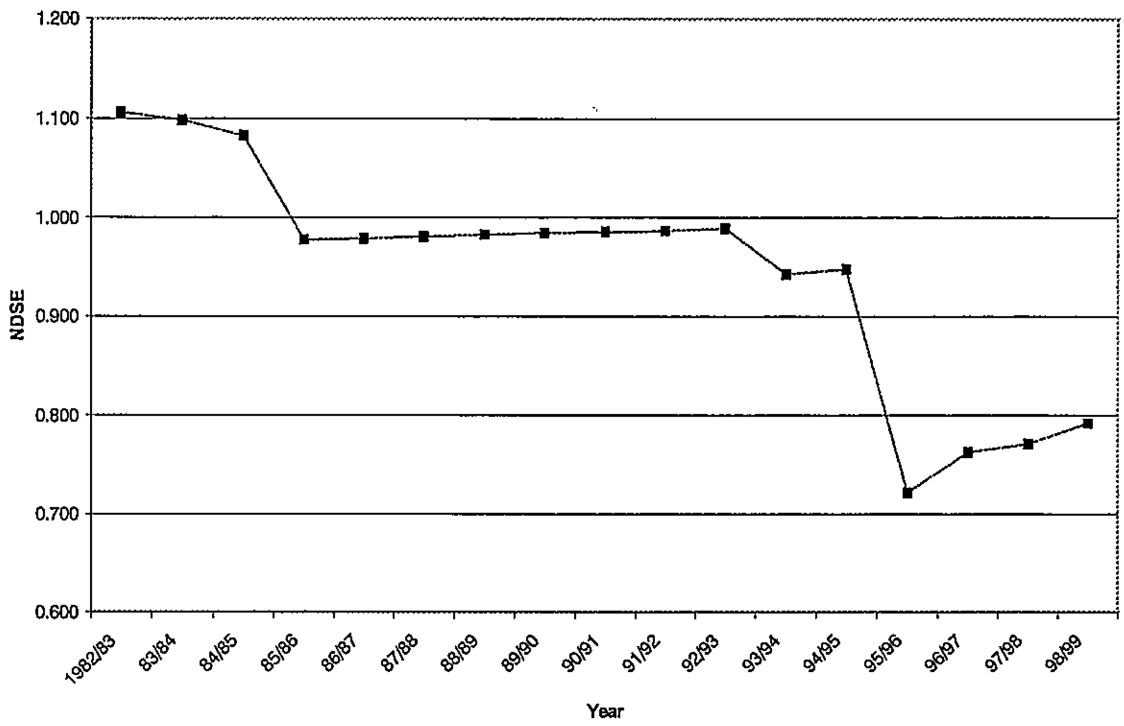


Figure 3: NDSE Over Time

## 5. Concluding remarks

We have examined the performance trend (cost efficiency) of Life Insurance Corporation of India for the period 1982-83 through 1998-99. The overall performance of LIC shows a significant heterogeneity visible in the NOSE pattern within 17 years covering before after economic liberalization is introduced. More importantly, there has been a downward trend in performance since 1994-95. This deterioration in performance is largely due to increasing allocative inefficiencies arising from poor management including leadership, management style, and decisional capability of LIC.

Insurance regulation in India has been taken as a challenge and necessity for the healthy growth of the industry. It is a challenge mainly because of lack of prior experience, and the need to build a strong and credible regulator who can assure new entrants of a level playing field in the presence of hitherto monopoly incumbents. This regulation has led life insurance business to compete with other contractual savings business such as banks and mutual funds. Our result of LIC running inefficiently may be due to the competition that it faces with banks and mutual funds, which is contrary to our general expectation. This finding calls into question the deregulation of publicly held monopoly LIC as redundant because the profit motive and guarding its monopoly status may not be paramount objectives to a public sector firm, and there may be in-built procedures in its operations to deal with issues normally addressed by a regulator.

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## Appendix A. Life Insurance in India

Life insurance in its existing form came in India from the United Kingdom (UK) with the establishment of a British firm, Oriental Life Insurance Company in Calcutta in 1818. Bombay Life Assurance Company in 1823, the Madras Equitable Life Insurance Society in 1829 and Oriental Government Security Life Assurance Company in 1874 followed this. Prior to 1871 Indian Lives were treated as sub-standard and charged an extra premium of 15% to 20% (Malhotra, 1994). Bombay Mutual Life Assurance Society, an Indian insurer that came into existence in 1871, was the first to cover Indian lives at normal rates.

By 1956, 154 Indian insurers, 16 non-Indian insurers and 75 provident societies were carrying on life insurance business in India. Life insurance business was confined mainly to cities and better off segments of the society.

On 19th January 1956, the management of life insurance business of 245 Indian and foreign insurers and provident societies, then operating in India, was taken over by the central government then nationalized on 1st September 1956. LIC was formed in September 1956 by an Act of Parliament, viz. LIC Act, 1956, with capital contribution of Rs.5 crores from the Government of India.

The Government of India appointed a Committee on Reforms in the Insurance sector under the chairmanship of the former governor of the Reserve Bank of India, Mr. R. N. Malhotra. The committee submitted its report to the Government of India, Ministry of Finance in January' 1994. According to the report, economic reforms, particularly those relating to the financial sector, raise several important issues regarding the insurance industry including, importantly, the following:

A majority of areas previously reserved for the public sector have been thrown open to the private sector to strengthen the forces of competition. Competition is growing in the banking sector, which already includes numerous public sector banks as well as private sector banks, both, Indian and foreign. A similar trend is also evident among non-banking financial institutions, including leasing companies, mutual funds, merchant banks, and other intermediaries dealing with security business. In contrast, life and general insurance companies remain state monopolies. LIC is a monolith. The question arises as to why the consumer of insurance services should not be provided a wider choice so that she can get the benefits of competition in terms of range of insurance products, lower price of insurance cover and better customer service.

## Appendix B. On the Cost-efficiency Model

In this appendix, we point out shortcomings of the traditional cost-efficiency model in DEA, and propose a new scheme for evaluating the cost performance. See Tone [39] for details.

### B.1 The traditional cost efficiency model

Given the input and output matrices $X = (x_{ij}) \in R^{m \times n}$ and $Y = (y_{ij}) \in R^{s \times n}$ with the input cost matrix $C = (c_{ij}) \in R^{m \times n}$, the cost efficiency (overall and scale efficiency, OSE) of a DMU$_o$ $= (x_o, y_o)$ is defined by $c_o x^* / c_o x_o$ where $x^*$ is the optimal solution of the following LP problem:

$$\begin{aligned} & \min c_o x \\ & \text{subject to } x \geq X\lambda \\ & \quad y_o \leq Y\lambda \\ & \quad \lambda \geq 0. \end{aligned}$$

The traditional cost model assumes, at least implicitly, that the cost vector $c$ of inputs is common to all DMUs. However, in actual situations like ours, input costs differ from DMU to DMU. If we apply this model to such situations, the resulted cost efficiency score exhibits irrationality as the following example demonstrates.

Suppose that DMUs A and B have the same inputs and outputs, i.e., $x_A = x_B$ and $y_A = y_B$. Assume further that the input cost of A is twice that of B for each input, i.e., $c_A = 2c_B$.

Under these assumptions we have:

<u>Proposition 1</u>. Both A and B have the same cost efficiency.

This sounds strange, since the cost of B is half that of A and hence its cost performance should be better than A. In order to resolve this difficulty we propose the following new scheme.

### B.2 A new cost efficiency scheme

Let us define a cost-based production possibility set $P_c$ as:

$$P_c = \left\{ (\bar{x}, y) \middle| \bar{x} \geq \bar{X}\lambda, y \leq Y\lambda, \lambda \geq 0 \right\}$$

where $\bar{X} = (\bar{x}_1, \ldots, \bar{x}_n)$ with $\bar{x}_j = (c_{1j}x_{1j}, \ldots, c_{mj}x_{mj})^T$.

We assume that $\bar{x}_{ij} = (c_{ij}x_{ij})$ $(\forall (i, j))$ has a common unit of cost, e.g., dollars, so that adding the elements of $\bar{x}_{ij}$ has meaning.

Based on this cost-based production possibility set, we define a new technical and scale efficiency $\bar{\theta}^*$ of DMU$_0$ as the optimal solution of the LP below:

$$[NTech_{crs}] \quad \min \overline{\theta}$$
$$\text{subject to } \overline{\theta x_o} \geq \overline{X}\lambda$$
$$y_o \geq Y\lambda$$
$$\lambda \geq 0.$$

The new cost efficiency (new overall and scale efficiency, NOSE) $\gamma^*$ is defined as

$$\overline{\gamma}^* = e\overline{x_o}^* / e\overline{x_o},$$

where $e \in R^m$ is a row vector with all elements equal to 1 and $\overline{x_o}^*$ is the optimal solution of the following LP:

$$[NCost_{vrs}] \quad \min e\overline{x}$$
$$\text{subject to } \overline{x} \geq \overline{X}\lambda$$
$$y_o \geq Y\lambda$$
$$\lambda \geq 0.$$

Proposition 2. The new cost efficiency is not greater than the new technical efficiency.

The new allocative and scale efficiency (NASE) $\overline{\alpha}^*$ is defined as the ratio $\overline{\gamma}^*$ vs. $\overline{\theta}^*$ :

$$\overline{\alpha}^* = \overline{\gamma}^* / \overline{\theta}^*.$$

We note that the new efficiency measures are all units invariant so long as $\overline{X}$ has a common unit of cost, e.g., dollar, yen or pound.

Proposition 3. (Monotonicity with respect to cost) If $x_A = x_B, y_A = y_B$ and $c_A \geq c_B$, then we have inequalities $\overline{\theta}_A^* \leq \overline{\theta}_B^*$ and $\overline{\gamma}_A^* \leq \overline{\gamma}_B^*$. Furthermore, strict inequalities hold if $c_A > c_B$.

Specifically, we have

Proposition 4. If $x_A = x_B, y_A = y_B$ and $c_A = kc_B (k > 0)$, then we have $\overline{\gamma}_A^* = \frac{1}{k}\overline{\gamma}_B^*$.

Proposition 5. If $x_A = kx_B (k > 0), y_A = y_B$ and $c_A = c_B$, then we have $\overline{\gamma}_A^* = \frac{1}{k}\overline{\gamma}_B^*$.

These properties offer rationality for considering the new cost efficiency scheme.