A Stochastic Frontier Model on Investigating Efficiency of Life Insurance Companies in India

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Abstract - The present paper attempts to investigate the efficiency of life insurance companies in India for the year 2011. An insurance company is said to be efficient if it produce maximum profit using minimum level of available resources. Due to new policies of Government of India, many new insurance companies emerged in Indian market which created a high competition among themselves, which made administrators to monitor their company's efficiency level over a period of times to make improvement or changes in their strategy to survive. Studying efficiency of an organization became pioneering area of research during the last several years. Among many frontier techniques *Stochastic Frontier Analysis* (SFA) is one of the best known techniques to determine the efficiency. The SFA results indicate that the efficient scores lie between the values 0.1244 to 0.9992; and the average efficient score for all 24 life insurance companies is 0.5767. The life insurance company LI03 is ranked first with the efficiency score of 0.9992 followed by LI11 with efficiency score of 0.9881. LI24 stands last with the efficiency score of 0.1244 (rank 24). The variables *investment* and *net claims* considered in the present study differ significantly at 5% level.

Key words: ***Stochastic Frontier Analysis, Profit Efficiency, Insurance Sector, Cobb-Douglas Function***

I. INTRODUCTION

In the past two decades, the insurance industry in India has witnessed numerous changes. For insurance industries as well as the policyholders, the year 2011 has been an eventful year. Few changes and guidelines enacted by the Indian government impacted the sector positively. The demand of insurance products slightly increased due to the exponential growth of household savings, middle class population, purchasing power and working population of country. At the same time, the deregulations and liberalization in Indian government policies, improvements in technology etc., made number of players enter this field which created a highly competitive market among insurance companies, which made administrators to monitor their own as well as competitors efficiency levels over interval of time to make improvement or changes in their strategy, if necessary, to survive.

Evaluation of a company's or firm's performance efficient level relative to other companies becomes more important research in last two decades. Many new scientific/non-scientific techniques are formulated to determine the efficient level. But yet there are many disputes among the techniques in declaring themselves as the most preferable method than other. Every method has its own assumption, conditions and limitations. Traditionally, financial ratio analysis based on key factors such as return on asset, return on equity, net profit etc., are used to estimate the efficiency and its major drawback is that comparison of companies is done individually. Recently, rapid development in frontier efficiency methodology attracted many researchers, and as a result, within in a short span of time many research articles are published using these methods. Frontier methodologies measure firms performance relative to "best practice" frontiers consisting of other firms in the industry [5]. There are two basic types of efficiency methodologies in frontier techniques namely, the econometric (parametric) approach and the mathematical programming (non parametric) approach. Stochastic frontier analysis (SFA), Thick frontier analysis (TFA) and Distribution free approaches (DFA) belong to parametric methods and they required the specification of cost, production, profit or revenue functions and also the assumptions about the error terms. Data envelopment analysis (DEA) and Free disposal hull (FDH) are grouped under non-parametric methods, and these methods do not need any specification and also they are linear programming method and hence it is very easy to understand. It is to be mentioned that both methods have their own advantages and disadvantages.

The primary objective of this study is to find the efficient insurance industries in the Indian market and to give suggestion for the improvement of inefficient companies. For this purpose, SFA is used as an estimation technique to determine the efficiency level of insurance industries in India.

Several studies have been conducted using SFA in different fields such as Hospitals (Schools, Sports etc.,..) [7] where both DEA and SFA are used to estimate the efficiency of hospitals (Schools, Sports etc.,..) and compared with each other. They suggested both the methods have particular strengths and weakness and potentially measure different aspects of efficiency. Frohloff [6] investigated both technical and cost efficiency for more than 1500 German general hospitals using SFA for the year 2000 to 2003 and found that private and non-profit hospitals are on the average less costly and technically efficient than publicly owned hospitals. Barrow [3] studied the efficiency of local education authorities by using both cross-sectional and panel data with stochastic and deterministic methods. In sports SFA applied vary effectively. Barros [2] combined both financial data and sport analysis the technical efficiency of English football premier league and suggested new policies for the improvement. Rathke and Woitek [12] applied SFA, estimate the important of sport in society as technical efficiency of countries in the production of Olympic success since the 1950. Kern and Sussmuth [10] used wage bills of players and coaches as independent and revenues and sporting success as dependent variable and estimated efficient level by applying SFA and found robust pattern of technical efficiency over subsequent seasons and also highlighted that instability of the German soccer industry. Jara, Paolini and Tena [8] studied the relative important of variables related to power and managerial decision by SFA for Chilean and Italian football. Shazali and Alias [13] reviewed the performance of productivity and efficiency the life insurance industry for the community in Malaysia.

This paper is organized as follows. Section 1 provides the introduction, objective and related studies, Section 2, gives the overview of life insurance companies in India and business performance for the year 2011. Brief introduction of proposed model is described in Section 3. Selection of variables, data and model for this study is provided in section 4 and 5. Section 6 discussed the empirical results and discussion and finally, Section 7 presents the conclusion of the present study.

II. AN OVERVIEW OF LIFE INSURANCE COMPANIES IN INDIA

Insurance has deep rooted history from ancient period in India and a clear picture can be seen from 1818 with the establishment of the Oriental Life insurance company in Kolkata by Europeans. This was the first insurance company in India. Following this, many insurance companies emerged but served only for the benefit of foreigners. Till the birth of first Indian life insurance company, Bombay Mutual Life Assurance Society in 1870, Indian lives were not covered under normal rate like foreigners. Swadeshi movement gave rise to many insurance companies like The United India in Madras, The Co-operative Assurance at Lahore, National Indian and National Insurance in Calcutta, General assurance, The Indian Mercantile, Hindustan Co-operative insurance company and Swadeshi life (Bombay life) etc. In the year 1912, a new era for insurance company began by passing the provident fund act and the Life insurance companies' act. Due to these acts premium rate tables and periodical valuations of insurance companies were made necessary. In 1928, another act called Indian insurance act was passed and this made Indian government to accumulate more information about the insurance companies which operated in Indian soil.

Due to no control or proper regulations over the insurance sector many new companies furnished within a short period of two decades of twentieth century. As companies and competition among companies' increased, many companies struggled a lot to survive and as a result, companies started to fail slowly. This paved the way to bring insurance act in 1938 and made both life and non-life insurance under strict control over their business practices. In 1956, government of India had taken a decision of nationalization of insurance company to stop the unfair trade practices. By merging 245 Indian, foreign insurers and provident societies are taken over by central government and through LIC act, Life Insurance Company of India (LIC) emerged. Till late 1990's LIC was the only insurance company in India.

Malhotra committee was formed in 1993 and made some reforms for the development in insurance sector. Following the committee's recommendation, private parties started insurance companies in India. Insurance market of India opened to foreign companies with a condition that not more than 26% stake in the joint venture with Indian companies. Based on committee's recommendation the insurance regulatory and development authority act brought in 1999 which made so many changes in insurance sector field. Insurance regulatory and development authority (IRDA) formed in the year 2000, its major goal is to safeguard the policyholder's interest and suggest new ideas for growth of insurance sector.

Today, in the Indian insurance market there are 24 life insurance companies including LIC, the sole public sector company. Table 2.1 gives some performance highlight of life insurance companies under Indian market for the FY 2011-12. In the following sections, definitions of production frontier and stochastic frontiers are reviewed and briefed.

TABLE I. BUSINESS PERFORMANCE OF PUBLIC AND PRIVATE LIFE INSURANCE COMPANY IN INDIA

	PUBLIC	PRIVATE
Premium Underwritten (Rs in Crores)	202889.28	84182.83
New Policies Issued (in Lakhs)	358.00	85.00
Number of Offices	3455	7712
Benefits Paid (Rs in Crores)	117497	35635
Individual Death Claims (Number of Policies)	731336	122864
Individual Death Claims Amount Paid (Rs in Crores)	6559.51	1849.23
Group Death Claims (Number of Policies)	244314	158093
Group Death Claims Amount Paid (Rs in Crores)	1586.75	794.99
Claim Settlement Ratio (in percent)	97.42	89.34

Source: Annual report from IRDA

III. BRIEF INTRODUCTION OF PROPOSED MODEL

A. PRODUCTION FRONTIER

The definition of production function is given as: *for a given set of minimum inputs there should exits maximum possible outputs*. A production function model can be written as

$$P_i = f(A_i, \beta)\, TE_i \qquad (1)$$
$$i = 1, 2, 3, \dots, N$$

where,

$P_i = Output\ of\ company\ i$

$A_i = A\ vector\ of\ M\ inputs\ used\ by\ company\ i$

$\beta = A\ vector\ of\ technical\ parameter\ to\ be\ estimated$

$f(A_i, \beta) = Production\ function$

$TE_i = Technical\ Inefficiency\ of\ company\ i$

Therefore, from (1) above can be written to find TE_i as

$$TE_i = \frac{P_i}{f(A_i, \beta)} \qquad (2)$$

From (2), TE can be defined as the ratio of observed output P_i to maximum feasible output $f(A_i, \beta)$. Suppose, $TE_i < 1$, then the company i is technically inefficient and when $TE_i = 1$, the company i is technically efficient.

As mentioned in Section 1, production frontier model $f(A_i, \beta)$ can be of two types such as deterministic or stochastic. Deterministic production frontier of the company i ignores fully the random shocks that are not under control. On the other hand stochastic production frontier includes the random shocks on the assumption that output can be affected by it. Production function based on stochastic model is

$$P_i = f(A_i, \beta) \exp(u_i) TE_i \qquad (3)$$

where, $f(A_i, \beta) \exp(u_i)$ is the stochastic frontier, which consists of a $f(A_i, \beta)$ (deterministic model) and $\exp(u_i)$ which captures the random shocks of company i.

Therefore, in order to find TE_i, equation (3) above can be written as

$$TE_i = \frac{P_i}{f(A_i, \beta) \exp(u_i)} \qquad (4)$$

The result of TE_i can be either 1 or less than 1. If $TE_i = 1$, the company i is technically efficient, else company i is technically inefficient with random shocks $\exp(u_i)$.

B. STOCHASTIC FRONTIER

The basic assumption underlying the measurement of technical efficiency using frontier method is that, a gap normally exists between a firm's actual and potential levels of technical performance. Stochastic frontier analysis were developed independently by ([9], [1] and [11]). Sometime the methodology is called as economic frontier approach (EFA). There basic idea is to add an error term in the production frontier with two components, first one allowing for technical inefficiency and second one to any random events that affect the producers. For the clear understanding of mathematical derivation of the model refer the following papers [1] and [4].

The stochastic frontier model used in this paper is based on [4]. They constructed the stochastic frontier function for the group of companies' data.

The model proposed is

$$P_{it} = A_{it}\beta + (R_{it} - E_{it})$$

$$i = 1, 2, 3, \dots, N \text{ and } t = 1, 2, 3, \dots, T$$

where,

P_{it} = Output of ith company in the tth time period.

A_{it} = N * 1 vector of input of the ith company in the tth time period.

β = N * 1 vector of unknown parameters to be estimated.

R_{it} and E_{it} are assumed to have normal and half-normal distribution.

R_{it} is traditional random error, assumed to be independently and identically distributed (iid) with mean 0 and variance σ_r^2. It captures measurement error, noise and other random effects which are not under the control of the company.

$E_{it} = (E_i \exp(-\eta (t - T))$

E_i is non-negative error term, assumed to be iid as truncations at 0 of the normal distribution with mean μ and variance σ_e^2 which captures the inefficiency. Both are representing the technical inefficiency and also R_{it} is independent of E_{it}. η is a parameter to be estimated.

The maximum likelihood method is applied for the estimation of the parameters of the model and predication of the efficiency. Frontiers of profit function is valid, subject to the variation of ratio γ is not zero $\left(\gamma = \frac{\sigma_e^2}{\sigma_e^2+\sigma_r^2}\right), \gamma \in (0,1)$. Frontier function is invalid, if the above condition is not meet. When γ is near to 0, efficiency of deviation mainly determined by the random error and when γ is close to 1, efficiency of deviation is mainly due to inefficient decision.

IV. SOURCES OF DATA AND SELECTION OF VARIABLES

To find the efficiency of life insurance companies in India, this study uses data from the income statement, balance sheets and other documents for the year 2011 extracted from annual report published in Insurance Regulatory and development Authority (IRDA) web page. The dataset consists of 24 life insurance companies in which 23 are private and one is public. Selection of variable is crucial because many studies based on SFA were referred and found that different parameters are used in the selection of variables for their studies. Variables which are appropriate and widely used in the literature are selected for this study. Table 4.1 provides the lists of the selected variables and its codes.

TABLE II. LISTS OF VARIABLES AND ITS CODE

S.NO	Variables	Codes
1	Total Profit	TPR
2	Net Investment income	NIV
3	Expenses	EXP
4	Total Liabilities	TLI
5	Annual Premium	APR
6	Net Claims	NCL

V. MODEL SPECIFICATION OF THE STUDY

By using Cobb-Douglas function, the stochastic frontier model for this study is constructed as follows.

$$\log P_{it} = \beta_0 + \beta_1 \log A_{1it} + \beta_2 \log A_{2it} + \beta_3 \log A_{3it} + \beta_4 \log A_{4it} + \beta_5 \log A_{5it} + R_{it} - E_{it}$$

where,

$\log P_{it} = Total\ Profit\ of\ the\ i^{th}\ insurance\ company\ in\ the\ t^{th}\ time\ period.$

$\beta = Unknown\ parameter\ to\ be\ estimated.$

$\log A_{1it} = Net\ Investment\ Income\ of\ the\ i^{th}\ insurance\ company\ in\ the\ t^{th}\ time\ period.$

$\log A_{2it} = Expenses\ of\ the\ i^{th}\ insurance\ company\ in\ the\ t^{th}\ time\ period.$

$\log A_{3it} = Total\ Liabilities\ of\ the\ i^{th}\ insurance\ company\ in\ the\ t^{th}\ time\ period.$

$\log A_{4it} = Annual\ Premium\ of\ the\ i^{th}\ insurance\ company\ in\ the\ t^{th}\ time\ period.$

$\log A_{5it}$ = *Net Claims of the* i^{th} *insurance company in the* t^{th} *time period.*

R_{it} = *Assumed to be iid* $N(0, \sigma_r^2)$ *and captures Statistical noise, measurement and other errors.*

E_{it} = *non negative random variables, associated with technical inefficiency of total profit of the companies.*

VI. RESULT AND DISCUSSION

A. DESCRIPTIVE ANALYSIS

Table 6.1.1 reports the descriptive statistics of the output and input variables of 24 life insurances companies in India during the period of study. In the study period, Insurance companies LI11 and LI4 had the highest and lowest value for the total profit. As far as the input variables

are concerned, LI7, LI19, LI8 had the lowest amount in Net Investment Income, Expenses, Total Liabilities, Annual Premium and Net Claims respectively and LI11, LI24 had highest amount in Net investment Income, Expenses, Total Liabilities, Annual Premium and Net claims. The range of mean of the variables is between 43874 and 4803410 and standard deviation lies between 46767 to 21783501.

TABLE III. DESCRIPTIVE ANALYSIS OF CHOSEN VARIABLES FOR THE YEAR 2011

S.NO	Variables Codes	Min	Max	Average	SD
1	TPR	0	157401	43874	46767
2	NIV	15807	107051086	4803410	21783501
3	EXP	3997	1491440	124364	295987
4	TLI	1266	3215830	185873	647543
5	APR	1088	20288928	1196134	4086672
6	NCL	1	11747214	636129	2376173

B. ESTIMATION RESULTS

Table 6.2.1 presents the maximum likelihood estimates for the parameters of stochastic production function. TPR is taken as dependent variable and estimated the production function of other variables. The estimated sigma-square (σ^2)

is 0.6774 and the p-value (Significance value) is 0.0018 which is less than 0.01 (ie., statistically different from zero at one percent). This result indicates that the one-sided error term dominates the symmetry error indicating a good fit and the correctness of the specified distributional assumptions.

TABLE IV. MAXIMUM - LIKEIHOOD ESTIMATES FOR PARAMETERS OF THE STOCHASTIC PRODUCTION FUNCTION

DEPENDENT VARIABLE: TOTAL PROFIT (TPR)

	Estimate	Std. Error	t value	Pr(>|t|)
Constant	5.0785	1.4494	3.5038	0.0005 ***
log(NIV)	0.4576	0.2037	2.2468	0.0247 *
log(EXP)	0.3356	0.2451	1.3694	0.1709
log(TLI)	-0.0082	0.6936	-0.0118	0.9906
log(APR)	-0.4240	0.3721	-1.1393	0.2546
log(NCL)	0.1813	0.0839	2.1602	0.0308*
Sigma Square	0.6774	0.2175	3.1150	0.0018 **
gamma	0.9412	0.1421	7.0377	0.0000 ***
Log likelihood Value	-13.4845			

Significant Codes: *** P < 0.001, ** P < 0.01, * P < 0.05

The coefficient value of gamma (γ) is 0. 0.9412 which is too close to one. This proved that inefficient in the composite error accounted for the vast majority, and random error accounts for a very small proportion. Therefore, it can be concluded that the technical inefficiency effects associated with the production of the total profits by the input of the life insurance companies are very high. Log likelihood value is -13.4845.

The results of MLE provided the information that the variables NIV, EXP and NCL are positively and TLI and APR are negatively related to TPR. The "t-test" showed that variables NIV and NCL are significant at 5% level and contribute more to TPR than other variables EXP, TLI and APR. The t-value for NIV is 2.2468 and P-value is 0.0247 which is less than 0.05. The coefficient value is 0.4576; this means that a unit increase in NIV results in an increase of 45.76% on the profitability of the insurance company. Similarly t-value of NCL is 2.1602 and P-value is (0.0308 < 0.05), the coefficient value is 0.1813; this means that 1% increase in NCL results in an increase of 0.1813% on the profitability of the insurance company.

TABLE V. RELATIVE EFFICIENCY SCORE AND RANKS OF LIFE INSURANCE COMPANIES IN INDIA

Companies Codes	Efficiency Score	Rank	Companies Codes	Efficiency Score	Rank
LI01	0.6523	09	**LI13**	0.6382	11
LI02	0.4179	18	**LI14**	0.1951	22
LI03	0.9992	01	**LI15**	0.5978	12
LI04	0.7922	07	**LI16**	0.5668	13
LI05	0.5668	14	**LI17**	0.3473	21
LI06	0.3683	20	**LI18**	0.6602	08
LI07	0.8273	06	**LI19**	0.8301	04
LI08	0.1686	23	**LI20**	0.5317	15
LI09	0.6523	10	**LI21**	0.8277	05
LI10	0.4247	17	**LI22**	0.8751	03
LI11	0.9881	02	**LI23**	0.4823	16
LI12	0.3811	19	**LI24**	0.1244	24
Mean Efficient score = 0.5767					

Table 6.2.2 provides the efficiency scores and ranks of life insurance companies in India. The result showed that the range of efficient scores is 0.1244 to 0.9992 and the overall average is 0.5767. For the twelve life insurance companies LI01, LI03, LI04, LI07, LI09, LI11, LI13, LI15, LI18, LI19, LI21 and LI22, the efficiency scores are above the overall mean efficient score. Based on the efficiency scores, life insurance companies are given ranks. LI3 ranked first with efficiency score of 0.9992 and it's followed by LI11 with 0.9881. The efficient score of LI24 is 0.1244 and stands last with rank 24 and it was preceded by LI8.

VII. CONCLUSION

This study estimates the efficiency level of 24 life insurance companies in India using econometric method Stochastic Frontier Analysis (SFA). Our objective is measure to investigate the relative efficiency of life insurance companies for the period of 2011. Considering TPR as output and NIV, EXP, TCL, APR and NCL input variables, the model is created. The results from maximum likelihood estimates provided that

- The coefficient value of Sigma-square (σ^2) is 0.6774 and t-test value is 3.1150, P-value is 0.0018 which is less than 0.01. Suggests that the one-sided error term dominates the symmetry error indicating a good fit and the correctness of the specified distributional assumptions.

- The coefficient value of gamma (γ) is 0. 0.9412 which is too close to one, indicates that the technical inefficiency effects associated with the production of the total profits by the input of the life insurance companies are very high and random error accounts for a very small proportion.

- The variables NIV, EXP and NCL are positively and TLI and APR are negatively related to TPR. The "t-test" showed that variables NIV and NCL are significant at 5% level and contribute more to TPR than other variables EXP, TLI and APR. The t-value for NIV is 2.2468 and P-value is 0.0247 which is less than 0.05. The coefficient value is 0.4576; this means that 1% increase in NIV results in an increase of 0.4576% on the profitability of the insurance company. Similarly t-value of NCL is 2.1602 and P-value is (0.0308 < 0.05), coefficient value is 0.1813; this means that 1% increase in NCL results in an increase of 0.1813% on the profitability of the insurance company.

The results of this study can also assessed by looking at the efficiency score and ranks obtained by each life insurance companies. Results suggest that the range of efficient scores is 0.1244 to 0.9992 and the overall average is 0.5767. For the twelve life insurance companies LI01, LI03, LI04, LI07, LI09, LI11, LI13, LI15, LI18, LI19, LI21 and LI22 efficiency scores are above the overall mean efficient score,. Based on the efficiency scores life insurance companies are given ranks. LI3 ranked first with efficiency score of 0.9992 and it's followed by LI11 with 0.9881. The efficient score of LI24 is 0.1244 and stands last with rank 24 and it was preceded by LI8.

This study provides an insightful view of companies' level. This helps the management of the insurance company to know their own as well as their competitor's positions in the field. Also, Managers can identify the weakness of the company and provide a better strategy to improve and attract more customers. Based on this analysis, the customers can also select the best insurance companies which are performing well in the market and benefit more.

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