Efficiency and Productivity Analysis of Indian Health Insurers: DEA and Malmquist Productivity Index (2019-22)

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Abstract— **The COVID-19 pandemic has had a significant impact on the global economy, including the health insurance industry in India. In this project, we analyze the efficiency and productivity of Indian health insurers in the period of 2019-2022 using Data Envelopment Analysis (DEA) and Malmquist DEA. We find that the average efficiency and productivity of the health insurance firms declines during the three years and different firms experience diverging trends.**

Keywords— *health insurers, COVID-19, data envelopment analysis (DEA), Malmquist DEA*

I. Introduction and Background

The COVID-19 pandemic's impact has been felt worldwide by firms across sectors. Primarily the healthcare sector was worst hit by the crisis. Its efficiency and productivity being compromised significantly, the Indian healthcare sector faced its greatest challenge of the twenty-first century. Therefore, it is imperative to identify what factors affect the efficiency and productivity of healthcare industry components during crises.

We restrict our focus on the Indian health insurance sector. The primary aim of this study is to analyse the trends in the efficiencies and productivities of health insurance firms in India from 2019 to 2022. Efficiency was measured by the technical efficiency score given by data envelopment analysis (DEA) models. We broke the chosen time period into three periods, i.e., one year each: Pre-pandemic, pandemic and post-pandemic. Other than efficiency, we focus on the change in the productivity of these firms by using the Malmquist Productivity Index. We assigned the year 2019-20 as the base year for the calculation of productivity index. We analyse 30 health insurers for our DEA analysis and 30 for Malmquist DEA initially, and then 29 firms excluding an anomalous firm.

The report proceeds as follows. The data and methods, including the DEA models and the Malmquist Productivity Index, are described in the following sections. The data presentation and empirical analysis that follows this part involves the formulation of the technical efficiency score and productivity score. Discussion of our productivity measures and conclusions are presented in the final part.

II. Literature Review

There have been many studies analysing the efficiencies of insurance firms in general using varied set of DEA methodologies across the world. Barros et al (2005) calculate the efficiencies and productivities using the Malmquist Index for Portuguese insurance companies, and their study serves as a baseline for other analyses and ours as well. Grmanova and

Strunz (2017) conduct a similar study in Slovakia and employ censored regression (Tobit regression) to analyse the interaction of profitability of firms and their efficiencies, a pathway which we were planning to undertake but the context of the pandemic made profitability analysis irrelevant. Our study closely follows the work of Siddiqui (2021) who conduct an efficiency analysis of health insurers using slack-based measurers (SBM) of data envelopment analysis, the study period just preceding ours, 2015 to 2019.

III. Data

We use from the Insurance Regulatory and Development Authority of India's (IRDAI) Handbook of Indian Insurance Statistics, which covers 32 Indian Health insurance firms for the years 2019 to 2022. Two DEA models were used to express the technical efficiency score; the output-oriented VRS model and input oriented VRS model. Operating Expenses (X1) and Claims incurred (X2) served as the inputs while net premium earned (Y1) served as the output.

IV. Methodology

A. *DEA Model*

The relative efficiency score is expressed using quantitative models called DEA models. They convert several inputs into numerous outputs using linear programming. They create a convex non-parametric data envelopment. The individuals that underwent analysis and are included in the data envelopment have an efficiency score of one. The participants that were examined but were not included in the data envelopment are ineffective. The ratio of the efficiency score to the data envelopment serves as a measure of their efficacy.

DEA models come in a variety of types. The fundamental kinds are CCR and BCC models. Constant returns to scale are the foundation of CCR models. The foundation of BCC models is the notion of variable returns to scale.

B. *Malmquist Productivity Index*

Malmquist Productivity Index is a non-parametric approach used to measure productivity changes over time by decomposing changes into technical efficiency and technological change components.

effch: Technical Efficiency Change - It measures the change in technical efficiency of a firm or decision-making unit (DMU) between two periods.

techch: Technological Change - It refers to the change in productivity that results from a change in technology or the use of new techniques in production.

pech: Pure Efficiency Change - It refers to the improvement or deterioration in technical efficiency of a decision-making unit (DMU) over time, while holding constant its input and output mix.

sech: Scale Efficiency Change - It refers to the change in productivity due to a change in the scale of operations or input/output levels over time.

tfpch: Total Factor Productivity Change - It refers to the change in productivity that is attributed to factors beyond technical and scale efficiencies, such as technology improvements or changes in managerial practices.

A value of tfpch >1 means the firm is growing, and a value of tfpch <1 means there is a decline, and tfpch = 1 means productivity is stagnant.

V. EMPIRICAL ANALYSIS

We began by expressing the descriptive statistics of the insurance company indicators. Table 1 includes the values.

Table 1. Descriptive statistics of insurance companies´ indicators

Indicators	Average		
	2019-20	2020-21	2021-22
Net Earned Premium (₹Crore)	1218.77	1438.018	1935.51
Claims Incurred (Net) (₹Crore)	1083.87	1350.671	2112.028
Operating Expenses (₹Crore)	1322.541	1474.462	1631.454
Total Assets (₹Crore)	11969.465	14194.718	15782.57
Total Number of Policies	596972.5	817545.276	780061.55

In 2021-22, all the health insurance companies had the highest values of net premium earned, claims incurred, operating expenses and total assets. But the total number of policies were highest in the year 2020-21.

Table 2. Descriptive statistics of efficiency score

Efficiency Scores	Number of Efficient Insurance Companies	Average of Efficiency Scores	Standard Deviation of Efficiency Scores
2019-2020 IO	9	0.775	0.203
2019-2020 OO	9	0.793	0.196
2020-2021 IO	9	0.769	0.205
2020-2021 OO	9	0.787	0.199
2021-2022 IO	7	0.722	0.206
2021-2022 OO	7	0.733	0.204

For the first two years i.e., for 2019-20 and 2020-21 both the input oriented and output oriented VRS model had nine efficient firms. But right after the pandemic number of efficient firms lowered to seven.

The table also gives information about the average technical efficiency score along with its standard deviation for all the three years with their respective input and output orientation model.

A. Efficiency Analysis

Table 3. VRS Technical Efficiency

| Insurers	VRS Technical Efficiency					
	2019-20		2020-21		2021-22	
	Input	Output	Input	Output	Input	Output
National Insurance Co. Ltd.	0.629	0.655	0.853	0.874	0.67	0.693
The New India Assurance Co. Ltd.	1	1	1	1	1	1
The Oriental Insurance Co. Ltd.	0.649	0.774	0.728	0.76	0.61	0.634
United India Insurance Co. Ltd.	0.712	0.833	0.852	0.867	0.691	0.711
Acko General Insurance Ltd.	0.507	0.494	0.48	0.472	0.537	0.543
Bajaj Allianz General Insurance Co. Ltd.	0.732	0.749	0.795	0.866	0.663	0.731
Cholamandalam MS General Insurance Co. Ltd.	1	1	0.475	0.498	0.338	0.349
Edelweiss General Insurance Co. Ltd.	0.418	0.42	0.53	0.519	0.531	0.521
Future Generali India Insurance Co. Ltd.	0.674	0.684	0.51	0.531	0.589	0.598
Go Digit General Insurance Ltd.	0.356	0.348	0.604	0.653	1	1
HDFC ERGO General Insurance Co. Ltd.^^	0.643	0.683	0.892	0.918	0.71	0.73
ICICI Lombard General Insurance Co. Ltd.	0.746	0.763	0.789	0.844	0.739	0.777
IFFCO Tokio General Insurance Co. Ltd.	0.597	0.635	0.624	0.671	0.527	0.543
Kotak Mahindra General Insurance Co. Ltd.	0.938	0.948	1	1	0.812	0.824
Liberty General Insurance Ltd.	0.604	0.616	0.689	0.715	0.617	0.632
Magma HDI General Insurance Co. Ltd.	0.453	0.507	0.707	0.772	0.641	0.677
Navi General Insurance Limited	1	1	1	1	1	1
Raheja QBE General Insurance Co. Ltd.	1	1	0.291	0.318	0.304	0.28
Reliance General Insurance Co. Ltd.	0.628	0.66	0.543	0.571	0.597	0.611
Royal Sundaram General Insurance Co. Ltd.	0.769	0.775	0.72	0.738	0.611	0.62
SBI General Insurance Co. Ltd.	0.936	0.942	0.737	0.752	0.613	0.638
Shriram General Insurance Co. Ltd.	1	1	1	1	1	1
Tata AIG General Insurance Co. Ltd.	0.733	0.759	0.774	0.793	0.683	0.701
Universal Sompo General Insurance Co. Ltd.	0.672	0.689	0.563	0.562	0.499	0.5
Aditya Birla Health insurance Co. Ltd.	1	1	1	1	0.814	0.814
Care Health Insurance Ltd.	0.963	0.967	1	1	0.983	0.987
ManipalCigna Health Insurance Co. Ltd.	0.88	0.88	0.922	0.922	0.883	0.882
Niva Bupa Health Insurance Co. Ltd.	1	1	1	1	1	1
Reliance Health Insurance Ltd.	1	1	1	1	1	1
Star Health & Allied Insurance Co. Ltd.	1	1	1	1	1	1

We calculated the VRS technical efficiency of all the 30 firms in the Indian Health Insurance business. There were six health insurers which were efficient throughout the pandemic both input and output oriented. Which are The New India Assurance Co. Ltd. Which is public sector company. Next is Navi General Insurance and Shriram General Insurance they both are private sector entity and lastly are Niva Bupa Health Insurance, Reliance Health Insurance and Star Health & Allied Insurance which are standalone health insurers.

There are two firms which were efficient pre-pandemic and both are from the private sector. They are Cholamandalam MS General Insurance Raheja QBE General Insurance.

During the pandemic there were two firms which were efficient, one was from private sector and one from standalone firm: Kotak Mahindra General Insurance and Care Health Insurance respectively.

Go digit was the only company from all the health insurers which got efficient only after the pandemic. It was from the private sector.

There was a standalone firm which was efficient before and during the pandemic, it was Aditya Birla Health Insurance. It belongs to the standalone domain.

Table 4. Average Efficiency Scores
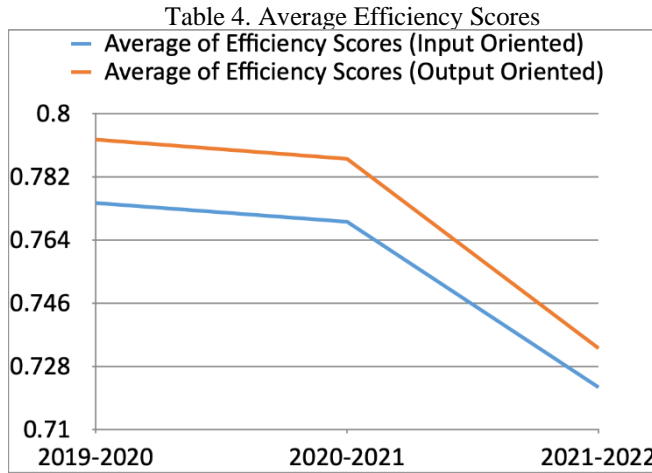
While we can observe that the average efficiency score i.e., both input and output oriented were decreasing. The rate of decline was less in 2020-21 as compared to 2021-22. Post pandemic it declined at a higher rate.

B. Productivity Analysis

As we discussed earlier that the year 2019-20 has been considered as the base year for the analysis of productivity. We performed the productivity analysis twice because there was an issue with our analysis, as the data for one firm was anomalous it caused error in the productivity change. Though we will show both the Malmquist Index results here to correct the issue we were encountering.

The first figure should the initial productivity analysis for the year 2020-21 and the next figure should the initial productivity analysis for the year 2021-22.

We can see from the figure that there is an issue with the firm number 22 which is Shriram General Insurance Co. Ltd. After a short analysis we came to find that the issue is with the data that we are using. During the pandemic year the firm's claims incurred were zero and this is the accounting issue which gave an unexpected result of a mean zero productivity for year 3 (2021-2022). Hence, we thought to drop the firm 22 and then perform the productivity analysis.

Table 4. v1_Year2_Productivity Table

year = 2

firm	effch	techch	pech	sech	tfpch
1	1.146	0.939	1.334	0.859	1.076
2	1.135	0.883	1.000	1.135	1.003
3	0.997	0.889	0.982	1.015	0.887
4	1.060	0.899	1.042	1.017	0.953
5	0.962	1.276	0.955	1.007	1.227
6	1.157	0.952	1.156	1.001	1.101
7	0.534	1.062	0.498	1.072	0.567
8	1.245	1.013	1.235	1.008	1.261
9	0.819	1.020	0.776	1.055	0.836
10	0.991	1.542	1.877	0.528	1.527
11	1.186	0.937	1.344	0.882	1.111
12	0.982	0.957	1.107	0.887	0.940
13	1.132	0.886	1.056	1.073	1.003
14	1.128	1.030	1.055	1.070	1.163
15	1.110	1.013	1.160	0.957	1.125
16	1.116	1.361	1.523	0.732	1.519
17	1.000	1.319	1.000	1.000	1.319
18	0.551	1.646	0.318	1.734	0.907
19	0.896	0.947	0.864	1.037	0.849
20	0.944	0.998	0.952	0.992	0.943
21	0.861	0.957	0.798	1.079	0.824
22	1.000	9.600	1.000	1.000	9.600
23	1.001	1.026	1.044	0.959	1.027
24	0.897	0.974	0.816	1.098	0.873
25	1.059	0.962	1.000	1.059	1.018
26	1.163	0.890	1.034	1.125	1.035
27	1.097	0.929	1.047	1.047	1.019
28	1.048	0.925	1.000	1.048	0.970
29	0.483	1.098	1.000	0.483	0.530
30	1.000	0.716	1.000	1.000	0.716
mean	0.968	1.099	0.991	0.977	1.063

Table 5. v1_Year3_Productivity Table

year =   3

firm	effch	techch	pech	sech	tfpch
1	1.119	0.984	0.793	1.410	1.101
2	1.118	1.040	1.000	1.118	1.163
3	1.094	0.989	0.834	1.311	1.082
4	1.047	0.929	0.819	1.277	0.973
5	1.136	0.887	1.151	0.987	1.008
6	0.899	0.904	0.844	1.065	0.812
7	0.780	0.872	0.700	1.114	0.680
8	1.007	0.888	1.005	1.002	0.894
9	1.173	0.874	1.125	1.042	1.025
10	2.050	0.825	1.532	1.338	1.692
11	1.024	0.963	0.796	1.287	0.987
12	1.002	0.898	0.921	1.088	0.899
13	0.845	0.941	0.810	1.044	0.796
14	0.808	0.877	0.824	0.980	0.708
15	0.953	0.867	0.884	1.079	0.827
16	1.036	0.835	0.876	1.182	0.865
17	1.000	0.784	1.000	1.000	0.784
18	1.022	0.788	0.882	1.159	0.806
19	1.106	0.888	1.071	1.033	0.982
20	0.894	0.879	0.841	1.063	0.786
21	0.841	0.909	0.848	0.991	0.764
22	1.000	0.000	1.000	1.000	0.000
23	1.018	0.872	0.884	1.152	0.888
24	0.887	0.903	0.888	0.998	0.801
25	0.839	0.905	0.814	1.031	0.760
26	0.962	0.908	0.987	0.975	0.874
27	0.950	0.914	0.957	0.993	0.868
28	1.000	0.914	1.000	1.000	0.914
29	0.302	0.754	1.000	0.302	0.228
30	1.000	1.205	1.000	1.000	1.205
mean	0.965	0.000	0.926	1.042	0.000

Table 6. v2_Year2_Productivity Table

year =   2

firm	effch	techch	pech	sech	tfpch
1	1.146	0.939	1.334	0.859	1.076
2	1.135	0.883	1.000	1.135	1.003
3	0.997	0.889	0.982	1.015	0.887
4	1.060	0.899	1.042	1.017	0.953
5	0.957	1.263	0.944	1.014	1.208
6	1.157	0.952	1.156	1.001	1.101
7	0.534	1.062	0.498	1.072	0.567
8	1.245	1.013	1.235	1.008	1.261
9	0.819	1.020	0.776	1.055	0.836
10	0.982	1.512	1.852	0.530	1.484
11	1.186	0.937	1.344	0.882	1.111
12	0.982	0.957	1.107	0.887	0.940
13	1.132	0.886	1.056	1.073	1.003
14	1.128	1.030	1.055	1.070	1.163
15	1.110	1.013	1.160	0.957	1.125
16	1.115	1.362	1.523	0.732	1.519
17	1.000	1.320	1.000	1.000	1.320
18	0.523	1.471	0.318	1.646	0.769
19	0.896	0.947	0.864	1.037	0.849
20	0.944	0.998	0.952	0.992	0.943
21	0.861	0.957	0.798	1.079	0.824
22	1.001	1.026	1.044	0.959	1.027
23	0.897	0.974	0.816	1.098	0.873
24	1.059	0.962	1.000	1.059	1.018
25	1.163	0.890	1.034	1.125	1.035
26	1.097	0.929	1.047	1.047	1.019
27	1.048	0.925	1.000	1.048	0.970
28	0.483	1.099	1.000	0.483	0.531
29	1.000	0.716	1.000	1.000	0.716
mean	0.965	1.014	0.990	0.974	0.978

Version 2 (v2) results are the second version of the Malmquist Productivity index analysis where we excluded the 22nd firm i.e., Shriram General Insurance Co. Ltd. because of the accounting issue which created an error to our analysis.

Table 7. v2_Year3_Productivity Table

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year =    3

  firm   effch  techch   pech   sech   tfpch

     1   1.119   0.984   0.793   1.410   1.101
     2   1.118   1.040   1.000   1.118   1.163
     3   1.094   0.989   0.834   1.311   1.082
     4   1.047   0.929   0.819   1.277   0.973
     5   1.136   0.887   1.151   0.987   1.008
     6   0.899   0.904   0.844   1.065   0.812
     7   0.780   0.872   0.700   1.114   0.680
     8   1.007   0.888   1.005   1.002   0.894
     9   1.173   0.874   1.125   1.042   1.025
    10   2.050   0.824   1.532   1.338   1.690
    11   1.024   0.963   0.796   1.287   0.987
    12   1.002   0.898   0.921   1.088   0.899
    13   0.845   0.941   0.810   1.044   0.796
    14   0.808   0.877   0.824   0.980   0.708
    15   0.953   0.867   0.884   1.079   0.827
    16   1.036   0.835   0.876   1.182   0.865
    17   1.000   0.779   1.000   1.000   0.779
    18   1.046   0.780   0.882   1.186   0.816
    19   1.106   0.888   1.071   1.033   0.982
    20   0.894   0.879   0.841   1.063   0.786
    21   0.841   0.909   0.848   0.991   0.764
    22   1.018   0.872   0.884   1.152   0.888
    23   0.887   0.903   0.888   0.998   0.801
    24   0.839   0.905   0.814   1.031   0.760
    25   0.962   0.908   0.987   0.975   0.874
    26   0.950   0.914   0.957   0.993   0.868
    27   1.000   0.914   1.000   1.000   0.914
    28   0.318   0.731   1.000   0.318   0.232
    29   1.000   1.205   1.000   1.000   1.205

  mean   0.966   0.898   0.923   1.046   0.868
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Now from the above figures we can see that we can interpret that in the year 2 (2020-21) during covid firm 16th i.e., Magma HDI General Insurance Co. Ltd. was the most productive firm out of the all other 29 firms. Second most productive firm is the Go Digit General Insurance Ltd.

And in the year 3 (2021-22) after covid is Go Digit General Insurance Ltd. During covid Go Digit was the second most productive firm. After the covid the second most productive firm is Star Health & Allied Insurance Co. Ltd.

We observed that the average productivity of the health insurers has decreased after the pandemic period. There could be various reason that why would have happened it.

VI. DISCUSSION AND CONCLUSION

In this study, the DEA framework has been used to assess the efficiences of health insurance firms in India from 2019 to 2020. This was the period of pre, during and post covid-19

pandemic. We observed that post the pandemic avergae technical efficiency of insurance companies dractically fall down as compared to earlier period. Pre and during the pandemic there were total nine firms which were efficient. But after the pandemic the total efficienct firms came down to seven.

We also calculated the Malmquist Productivity Index for the Health Insurance firms in India to find the productivity of companies during and post pandemic as compared to the pre pandemic levels. We found that the average productivity has declined after the pandemic as compared to the during pandemic period. We also observed that there were many firms which were have a growth in the productivity during the pandemic but after the pandemic the many firms declined their productivity and hence because of this number firms growing reduced drastically. This was one of the unique result of our analysis. The possible reason to this can be because there is some sort of lag in the input and output parameters which were considered for the analysis.

However, our study has some limitations. Such as the there were very less input and ouput variables which were considered for the analysis. The analysis could have had been more informative if more input and output parameters had been identified and used. For further studies we can use Tobit analysis to find out the relation between the profitability and the technical efficiency.

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