

Efficiency Changes of Pharmaceutical Companies in Bangladesh: An Application of Malmquist Indices

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Abstract

Research purpose: This research seeks to assess the efficiency changes of the pharmaceutical companies in Bangladesh over the study period.

Design/methodology/approach: The study collects secondary data from 11 randomly selected pharmaceutical companies out of 34 listed on the Dhaka Stock Exchange (DSE). The present research spans the period from 2014 to 2023. It employs Data Envelopment Analysis (DEA)-based Malmquist Indices (MI) to analyze efficiency changes.

Findings: The empirical findings reveal overall positive efficiency improvements of the sampled pharmaceutical companies, with increases of 97 per cent in technical efficiency, 28 per cent in technological efficiency, 1 per cent in pure efficiency, 59 per cent in scale efficiency, and 97 per cent in total factor productivity during the study period. The research's significant findings underscore the pharmaceutical companies' efficiency landscape in terms of gross profit, highlighting the role of independent variables such as cost of goods sold, share capital, total liabilities, operating expenses, and total assets.

Originality/value: The study offers a comprehensive analysis of efficiency changes in DSE-listed pharmaceutical companies in Bangladesh. It provides original insights into the key factors driving productivity growth in the industry.

Practical implications: This study suggests developing appropriate policies and making necessary adjustments to improve the efficiency score of the underlying pharmaceutical companies, thereby promoting competitiveness and sustainable growth in both domestic and international healthcare markets.

Research limitations: This study is limited by its relatively small sample size of 11 pharmaceutical companies in Bangladesh, which spans a 10-year study period from 2014 to 2023. On the other hand, for measuring efficiency changes, only DEA-based MI is used.

Keywords: Malmquist indices analysis, Efficiency changes, Pharmaceutical companies, Total factor productivity

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1. Introduction

In recent decades, the pharmaceutical industry has emerged as a crucial player in global healthcare systems, providing essential medicines and making significant contributions to economic growth. Bangladesh's pharmaceutical sector has undergone substantial growth and transformation, becoming a vital component of the nation's economy and healthcare infrastructure (Ahmed et al., 2018). Accessible and cheap healthcare, the opportunity for export to neighbouring countries, and the expanding local need for medicine are driving factors behind the growth of this industry (Rahman et al., 2020). However, industrial sustainability requires optimal resource utilization for maximum output (Hasan and Raihan, 2019). The rising healthcare strain is required to mushroom the pharmaceutical companies in Bangladesh, which has shaped deafening antagonism among the market contestants. As a result, to ensure fair entry to healthcare services and sustainable escalation, it is vital to strengthen the efficiency dynamics of this industry.

Among the several methods to gauge and match efficiency changes in firms, data envelopment analysis (DEA)-based Malmquist Indices (MI) is a noteworthy measuring apparatus (Hashimoto and Haneda, 2008). It is a non-parametric system that gives a dependable outline for assessing firm efficiency and productivity alteration over time. The MI proposes imminent changes in the factors that manipulate performance changes within firms by flouting down changes in total factor productivity (TFP) into mechanisms associated with technological growth and changes in technical efficiency. Considering the mounting significance of pharmaceutical companies in civic health outcomes and their latent role in the state economy, the present study endeavours to put into the academic literature on healthcare efficiency in Bangladesh.

Efficiency examination provides an outline for appraising a firm's capability to use output best while minimizing the employment of inputs. From the standpoint of the pharmaceutical industry, such analysis examines how efficiently firms switch resources—including labour, raw materials, and capital expenditures—into indispensable pharmaceutical goods (Ndiaye et al., 2017). Firms improve and monitor their progress towards the best use of resources by analyzing changes in efficiency over time (Coelli and Rao, 2005). The Malmquist Productivity Index (MPI) is an appraisal tool to assess efficiency boosts in businesses and industries (Fare et al., 1989). This non-parametric method divides productivity increase into two distinct components: technical efficiency change (TEC) and technological change (TC). TEC measures a firm's capability to arrive at its production frontier, demonstrating advances in internal procedures and resource allocation (Assaf and Tulkcu, 2017). In contrast, TC confines advances in industry knowledge and technology, allowing for increased output with the same amount of inputs (Dutta et al., 2015).

The MI has been applied to evaluate the efficiency and changes efficiency in many businesses across the globe (Cooper et al., 2007; Nimalathasan, 2009; Pannu et al., 2011; Oliveira et al., 2012; Mazumdar, 2013; Doraisamy et al., 2014; Eslami and Khoveyni, 2014; Uddin, 2015; Lema, 2016; Naz et al., 2017; Karimi, 2018; Pal et al. 2018; Abolghasem et al., 2019; Jahan, 2019; Hasan et al., 2019; Mahajan, 2020; Cristea et al., 2021; Hosen et al.,

2021; Pathak, 2019; Yu et al., 2021; Azam, 2021; Putri, 2022; Walheer, 2022; Tigga and Sarkar, 2024; Sun et al., 2024; Wang and Lee, 2025) analyzed efficiency changes, emphasizing the significance of technical developments in driving productivity augment. Similarly, Wanke et al. (2018) explored the Chinese pharmaceutical company's efficiency dynamics in resource management.

Most of the existing research on pharmaceutical efficiency changes tends to focus on countries outside of Bangladesh. In particular, there's an evident lack of studies using dynamic methods—like the Malmquist Index—to track how efficiency changes over time in the Bangladeshi pharmaceutical sector. Additionally, many previous studies cover only short time periods, which limits the depth and breadth to which their findings can be applied. To fill these gaps, this study utilizes the Malmquist Index over a ten-year period to provide a more comprehensive and time-sensitive understanding of how efficiency has evolved in Bangladesh's pharmaceutical industry.

This study uses the Malmquist Indices technique to assess the efficiency changes of selected pharmaceutical companies in Bangladesh over a distinct period. The research specifically seeks to identify areas where these companies can enhance their efficiency in resource utilization. Additionally, it aims to provide actionable recommendations to pick up the overall efficiency and competitiveness of the pharmaceutical sector in Bangladesh. The findings hold significant implications for policymakers, industry leaders, and researchers, guiding strategies towards enhanced efficiency and long-term sustainability of the pharmaceutical industry.

This article is structured to present the research in a clear and logical manner. It starts with the introduction, which explains the background, purpose, and goals of the study. Next, the literature review discusses previous research and identifies the gaps this study aims to fill. The methodology section outlines the source of the data, the selection process for the sample, the input and output variables used, and introduces the conceptual framework based on the Malmquist Index. The data analysis and interpretation section describes how the data were analyzed to track changes in efficiency. The results and discussion section presents the main findings and relates them to existing studies. Finally, the article concludes with a section on conclusion and recommendations, highlighting key insights and suggesting areas for future research and policy considerations.

2. Literature Review

This study has reviewed empirical literature to explore the research gap concerning efficiency evaluation and changes inefficiency by applying DEA-based MI techniques at the national and international levels. The reviewed literature highlights that the DEA techniques have been used in different sectors, including the pharmaceutical industry. Some of the relevant studies are focused here.

Sun et al. (2024) utilized a three-stage DEA and Malmquist Index to assess the operational efficiency of pharmaceutical companies in China. The study revealed low overall efficiency with significant annual fluctuations, underscoring the need for continuous

technological innovation and improved management practices to enhance productivity. Walheer (2022) introduces a global Malmquist Index (MI) for group contexts and proposes a Global Cost MI (GCMI) for economically optimized decision-making units (DMUs).

Wang (2025) assesses how efficiently township health centres in China performed between 2018 and 2022. A method called the Malmquist Index found that overall productivity, to some degree, dropped, especially in technical and scale efficiencies. Coastal areas performed the best among different regions, while northeastern regions exhibited the lowest efficiency levels.

Azam (2021) assessed the economic efficiency of the pharmaceutical industry in Bangladesh by analyzing data from nine pharmaceutical companies between 2015 and 2019 using the Malmquist Productivity Index. The findings of this study show a decline in total factor productivity due to inefficiencies in utilizing production factors like capital and labour despite improvements in operational efficiency and resource utilization. Azam (2021) explored productivity growth, efficiency changes, and technical progress within the corporate sector in Bangladesh using the same approach. The study highlights that while certain firms demonstrated efficiency gains, the overall productivity growth was hindered by technological stagnation in the corporate sector in Bangladesh.

Tigga and Sarkar (2024) examine the efficiency and productivity of the health system implementation in India using bootstrap data envelopment analysis and MPI. This study finds a technical efficiency score of 0.76, indicating that outputs could be increased by 24 per cent without additional inputs. However, the study observed a decline in productivity, primarily due to technological regress.

Wang and Lee (2025) applied the Malmquist Index to assess carbon emission efficiency in animal husbandry. While their study is not directly related to pharmaceuticals, the methodological framework can be adapted to analyze efficiency changes in the pharmaceutical industry, particularly regarding environmental sustainability. Adugna et al. (2024) explored the impact of performance-based financing on the efficiency of health centres in Ethiopia using the Malmquist Productivity Index. Their analysis revealed that performance-based financing led to significant improvements in efficiency, primarily through technological advancements in health centres.

Cristea et al. (2021) find a decline in efficiency change but an improvement in technical change for most enterprises in the Romanian construction companies from 2006 to 2019 using the Malmquist Productivity Index. Octrina and Mariam (2021) apply the Malmquist Index to assess Indonesia's Islamic banking industry's productivity. With a sample of 11 banks, the research work finds that the sector has reached a productive stage, as indicated by a high average total factor productivity change score.

Jahan (2019) appraises the productivity recital of 29 listed commercial banks in Bangladesh from 2011 to 2015 using the Malmquist Productivity Index (MPI) to measure Total Factor Productivity (TFP). The study finds that Islamic banks had a higher cumulative average TFP change than conventional banks.

Using microdata from European firms, Díaz and Sanchez-Robles (2020) analyze the efficiency recital of the pharmaceutical industry based on the non-parametric DEA. The study finds that overall efficiency in the sector is moderate, acknowledging the constraint of focusing solely on European firms.

The reviewed studies in this section suggest that DEA is a widely accepted tool for analyzing firm performance in the context of comparative efficiency. Despite some existing studies on the efficiency evaluation of industry in Bangladesh, the reviewed literature explores a study gap to identify the over-time efficiency variation among the pharmaceutical companies in Bangladesh. Accordingly, this research intends to close this gap by employing the Malmquist Indices that dissect productivity change into technical efficiency changes, technological development, pure efficiency changes, scale efficiency changes and total factor productivity. The findings of this study are relevant to a deeper understanding of the factors driving productivity growth in the pharmaceutical industry in Bangladesh and underscore an insightful suggestion for the sustainable development of this industry in Bangladesh

3. Methodology of the Study

3.1 Data Source

This study examines the changes in the efficiency of pharmaceutical firms in Bangladesh from 2014 to 2023. The secondary data for the study are collected from the financial reports, annual statements, and disclosures of the pharmaceutical companies.

3.2 Population and Sample of the Study

All the 34 pharmaceuticals and chemicals companies listed in DSE are considered as population. Among them, approximately one-third (eleven) companies are selected as samples. The stratified random sampling method is used when choosing the sample, and only the pharmaceutical companies are considered. The selected pharmaceutical companies are Square Pharmaceuticals Limited, Beximco Pharmaceuticals Limited, Beacon Pharmaceuticals Limited, Ambee Pharmaceuticals Limited, Renata Limited, IBN SINA Limited, ORION Pharma Limited, Pharma Aids Limited, Central Pharmaceuticals Limited, ACI Limited, and ACME.

3.3 Variables Selection

In the DEA analysis, it is essential to identify the underlying variables that highly influence the firm's performance. There are always several approaches to do this. This study applies Bayesian Model Averaging (BMA) techniques to the estimated three linear panel models with dependent variables: gross profit, net profit (profit after tax), and return on investment. The posterior inclusion probability (PIP) suggests that the best-fitted model is for the dependent variable gross profit with the independent variables cost of goods sold (COGS), share capital (SC), total liability (TL), operating expense (OE), and Total assets (TA), from the analysis of the best 500 estimated BMA models, based on the higher values of the

PIP and consistent with the sign of the coefficients, the study incorporates these variables in the estimated linear panel model.

3.4 Analyzing and Interpretation of Data

The study employed relevant analytical tools, including regression and DEA-based Malmquist Indices, to analyze, process, and interpret the data. This study analyzed data using statistical software, including MS Excel, STATA version 17, R version 4.3.0, and DEA software version 2.1.

3.4.1 Malmquist indices

The Malmquist Index (MI) is calculated using distance functions, which provide a flexible framework for analyzing productivity within a multi-input, multi-output production setting (Fare et al., 1994). The DEA-based Malmquist Productivity Index (MPI) serves as an effective analytical tool for examining efficiency and productivity changes over time (Palečková, 2017). The MI comprises several key components to capture different aspects of productivity change. These include Technical Efficiency Change (Effch), Technological Efficiency Change (Techch), Pure /Managerial Efficiency Change (Pech), Scale Efficiency Change (Sech), and Total Factor Productivity Change (Tfpch) (Raphael, 2013). The total factor productivity changes (Tfpch) at time t+1 and t by using input-oriented DEA-MI can be expressed as:

$$MI_0 = \left[\frac{D_0^t(x_0^{t+1}, y_0^{t+1})}{D_0^t(x_0^t, y_0^t)} \times \frac{D_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{D_0^{t+1}(x_0^t, y_0^t)} \right]^{\frac{1}{2}}$$

Source: Wang and Lan, 2011

Here, $MI_0 > 1$ indicates an improvement in Total Factor Productivity Change (Tfpch) from period t to t+1, while an MI_0 value =1 suggests no change in productivity over the two periods. Conversely, an $MI_0 < 1$ reflects a decline in Tfpch between period t and t+1. In addition to Tfpch, the Malmquist Index framework also allows for the appraisal of other components of efficiency change, including Effch, Techch, Pech, and Sech. Specifically, Tfpch can be decomposed into Effch and Techch, whereas Effch can further be decomposed into Pech and Sech, enabling a more detailed analysis of the sources of productivity change.

3.4.2 Conceptual framework of Malmquist Indices

This section outlines the conceptual framework of Malmquist Indices.

Technical efficiency: Technical efficiency reflects how well a firm utilizes its inputs to produce the highest possible output (Tung, 2013). It demonstrates the capacity to achieve maximum output with available inputs and existing production technology (Amaza and Maurice, 2005, cited in Anang et al., 2016). According to Erena et al. (2021), technical efficiency is a firm's ability to bring the maximum possible output with a specific level of inputs and technology.

Technological efficiency: The Malmquist Productivity Index (MPI) appraises technological efficiency by analyzing how much a firm improves its viable input-output mismatches along the productivity frontier (Balk, 2001). Technological advancements allow firms to produce more output with the optimal combination of inputs, shifting the production possibility frontier uphill (Worthington, 2000).

Pure or managerial efficiency: Managerial efficiency pertains to generating optimal societal and financial conditions within the organization to accomplish established goals and strategies while minimizing resource expenditures (Cheymetova and Scherbakov, 2017). It typically measures the firm's effectiveness in tumbling input consumption or maximizing output with minimal inputs (Atristain, 2012).

Scale efficiency: Scale efficiency indicates whether a firm operates at an optimal size. It shows that the organization scale is ideal, with any adjustments potentially reducing efficiency (Caunic, 2020). Scale efficiency is determined by the aggregate (overall) efficiency ratio to technical efficiency.

Total Factor Productivity (TFP): TFP measures the output-to-input ratio, capturing the overall productivity level and its changes over time (Fan et al., 2021). TFP reflects the percentage of output not directly attributed to the quantity of inputs, indicating how effectively and intensively inputs are utilized in production (Comin, 2008; Şeker and Saliola, 2018). The TFP value thus signifies the efficiency and intensity of input usage (Şeker and Saliola, 2018).

4. Results and Discussion

This study used the Malmquist Indices to examine changes in technical efficiency, technological efficiency, managerial or pure efficiency, scale efficiency and total factor productivity of pharmaceutical companies in Bangladesh.

4.1 Technical Efficiency Changes

Table 1 compares the changes in technical efficiency of the selected PHCs over the study period. Technical efficiency describes how effectively a specific set of inputs is used to generate a given output. A firm is considered technically efficient compared to others if it can generate the maximum output from the same types of inputs or produce the same output using the minimum amount of inputs, such as labour, capital, investment, and technology. In this context, the highest change in technical efficiency is observed in ACI, with a remarkable increase of 9180 per cent in 2022, followed by BEACON (230 per cent) in 2021, AMBEE (208 per cent) in 2021, BEXIMCO (143 per cent) in 2021, SQUARE (119 per cent) in 2021, IBN SINA (47 per cent) in 2020, PHARMAAIDS (37 per cent) in 2017, ORION (23 per cent) in 2020, ACME (17 per cent) in 2015, RENATA (13 per cent) in 2022, and CENTRAL (10 per cent) in 2018. The most significant decrease in technical efficiency was 99 per cent for ACI in 2021, while the minor decline was 6 per cent for ACME in 2022.

Table 1: Comparative technical efficiency changes in the selected PHCs

Companies	Year										Mean	Max.	Min.
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023			
SQUARE	-	1.13	0.76	1.33	1.00	1.00	0.46	2.19	1.00	1.00	1.10	2.19	0.46
BEXIMCO	-	1.12	0.82	1.24	1.00	1.00	0.41	2.43	1.00	0.97	1.11	2.43	0.41
BEACON	-	1.00	0.90	1.11	1.00	1.00	0.28	3.30	1.10	1.00	1.19	3.30	0.28
AMBEE	-	1.00	1.00	1.00	1.00	1.00	0.30	3.08	1.05	0.97	1.16	3.08	0.30
RENATA	-	1.00	0.99	1.01	0.96	1.04	1.00	0.89	1.13	1.00	1.00	1.13	0.89
IBN SINA	-	1.01	1.01	1.00	0.78	0.88	1.47	0.91	1.10	0.97	1.01	1.47	0.78
ORION	-	1.00	0.90	1.12	1.00	0.80	1.23	0.89	1.15	1.00	1.01	1.23	0.80
PHARMAAIDS	-	1.00	0.63	1.37	1.15	1.00	0.99	0.97	1.04	1.00	1.02	1.37	0.63
CENTRAL	-	1.00	1.00	0.90	1.10	1.01	1.00	0.96	1.04	0.97	1.00	1.10	0.90
ACI	-	1.00	0.99	0.93	1.08	1.01	1.00	0.01	92.80	1.00	11.09	92.80	0.01
ACME	-	1.17	1.00	1.00	1.00	1.00	1.00	1.00	0.94	1.07	1.02	1.17	0.94
Mean	-	1.04	0.91	1.09	1.01	0.98	0.83	1.51	9.40	1.00	1.97	10.11	0.58
Max.	-	1.17	1.01	1.37	1.15	1.04	1.47	3.30	92.80	1.07	11.09	92.80	0.94
Min.	-	1.00	0.63	0.90	0.78	0.80	0.28	0.01	0.94	0.97	1.00	1.10	0.01

Source: Authors' calculations based on data from annual reports of selected companies

The mean change in technical efficiency indicates that the highest increase is 1009 per cent for ACI. Conversely, the maximum decrease is observed in RENATA and CENTRAL, with no change occurring, as reflected by a 0 per cent change in both cases. The mean technical efficiency change for the remaining eight companies during the study period are SQUARE (10 per cent), BEXIMCO (11 per cent), BEACON (19 per cent), AMBEE (16 per cent), IBN SINA (1 per cent), ORION (1 per cent), PHARMAAIDS (2 per cent), and ACME (2 per cent). When examining the year-wise changes in mean technical efficiency, the results are: 4 per cent for 2015, -0.9 per cent for 2016, 9 per cent for 2017, 1 per cent for 2018, -2 per cent for 2019, -17 per cent for 2020, 51 per cent for 2021, 840 per cent for 2022, and no change for 2023. The sample shows a positive shift of 97 per cent in technical efficiency over the study period.

4.2 Technological Efficiency Changes

Table 2 illustrates the comparative changes in technological efficiency of the selected pharmaceutical companies during the study period. Technology refers to firms' methods and processes to produce goods and/or services. A firm is considered technologically efficient when it achieves a specific output level with the least input. In this context, the highest change in technological efficiency is observed in PHARMAAIDS (1434 per cent) in 2019, followed by IBN SINA (367 per cent) in 2020, CENTRAL (291 per cent) in 2020, ACME (278 per cent) in 2020, ORION (276 per cent) in 2020, and ACI (274 per cent) in 2020. Other companies include SQUARE (123 per cent) in 2022, RENATA (115 per cent) in 2020, AMBEE (60 per cent) in 2016, BEACON (36 per cent) in 2016, and BEXIMCO (32 per cent) in 2016. The most significant decrease in technological efficiency was 93 per cent for SQUARE in 2023, while the minor decline was 18 per cent for ACME in 2021.

Table 2: Comparative technological efficiency changes in the selected PHCs

Companies	Year										Mean	Max.	Min.
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023			
SQUARE	-	0.57	1.29	1.01	0.54	0.87	1.15	0.75	2.23	0.07	0.94	2.23	0.07
BEXIMCO	-	0.53	1.32	1.01	0.58	0.92	1.20	0.74	0.59	0.33	0.80	1.32	0.33
BEACON	-	0.47	1.36	1.02	0.52	0.94	1.18	0.74	0.38	0.84	0.83	1.36	0.38
AMBEE	-	0.42	1.60	1.05	0.50	1.00	1.12	0.74	0.70	0.72	0.87	1.60	0.42
RENATA	-	0.40	1.50	1.48	0.34	1.03	2.15	0.73	0.80	0.69	1.01	2.15	0.34
IBN SINA	-	0.42	1.37	1.28	0.38	1.51	4.67	0.70	0.80	0.80	1.33	4.67	0.38
ORION	-	0.43	1.22	1.26	0.52	1.26	3.76	0.73	0.80	0.90	1.21	3.76	0.43
PHARMAAIDS	-	0.44	1.33	1.22	1.08	15.34	0.12	0.71	0.91	0.96	2.45	15.34	0.12
CENTRAL	-	0.43	2.61	1.23	1.06	1.66	3.91	0.73	0.90	0.92	1.49	3.91	0.43
ACI	-	0.44	2.86	1.31	1.11	1.72	3.74	0.92	0.70	0.90	1.52	3.74	0.44
ACME	-	1.06	2.63	1.44	1.18	1.67	3.78	0.82	0.93	0.91	1.60	3.78	0.82
Mean	-	0.51	1.74	1.21	0.71	2.54	2.43	0.75	0.88	0.73	1.28	3.99	0.38
Max.	-	1.06	2.86	1.48	1.18	15.34	4.67	0.92	2.23	0.96	2.45	15.34	0.82
Min.	-	0.40	1.22	1.01	0.34	0.87	0.12	0.70	0.38	0.07	0.80	1.32	0.07

Source: Authors' calculations based on data from annual reports of selected companies

The mean change in technological efficiency indicates that the largest change is 145 per cent for PHARMAAIDS. Conversely, the maximum decrease is observed in BEXIMCO, with a decline of 20 per cent. The mean technological efficiency changes for the other nine companies during the study period are: SQUARE (-6 per cent), BEACON (-17 per cent), AMBEE (-13 per cent), RENATA (1 per cent), IBN SINA (33 per cent), ORION (21 per cent), CENTRAL (49 per cent), ACI (52 per cent), and ACME (60 per cent). The year-wise changes in mean technological efficiency are: -49 per cent for 2015, 74 per cent for 2016, 21 per cent for 2017, -29 per cent for 2018, 154 per cent for 2019, 143 per cent for 2020, -25 per cent for 2021, -12 per cent for 2022, and -27 per cent for 2023. However, the overall change for the sample during the study period was a positive 28 per cent.

4.3 Pure or Managerial Efficiency Changes

Table 3 presents a comparative investigation of the changes in pure efficiency among the selected pharmaceutical companies during the study period from 2014 to 2023. Pure efficiency refers to the ability of management to optimize its capacity, skill, and capability in directing the firm effectively. A firm is considered pure efficient compared to others if it can achieve maximum output using the same types and quantities of inputs. In this context, the most significant change is observed in ACI (66 per cent) in 2022, followed by ACME (44 per cent) in 2017, BEACON (35 per cent) in 2021, IBN SINA (28 per cent) in 2019, SQUARE (16 per cent) in 2017, AMBEE (16 per cent) in 2021, BEXIMCO (9 per cent) in 2017, RENATA (3 per cent) in 2022, ORION (1 per cent) in 2022, CENTRAL (1 per cent) in 2019 and PHARMAAIDS (0 per cent) that means no changes occurred in the study period. The maximum decreasing position was 40 per cent for ACI in 2021 and a minimum of 1 per cent for ORION in 2021.

Table 3: Comparative pure efficiency changes in the selected PHCs

Companies	Year										Mean	Max.	Min.
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023			
SQUARE	-	1.00	0.86	1.16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.16	0.86
BEXIMCO	-	0.99	0.92	1.09	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.09	0.92
BEACON	-	1.00	0.91	1.10	1.00	1.00	0.74	1.35	1.00	1.00	1.01	1.35	0.74
AMBEE	-	1.00	1.00	1.00	1.00	1.00	0.86	1.16	1.00	0.99	1.00	1.16	0.86
RENATA	-	1.00	0.99	1.01	1.00	1.00	1.00	0.97	1.03	1.00	1.00	1.03	0.97
IBN SINA	-	1.00	1.00	1.00	0.78	1.28	1.00	1.00	1.00	0.97	1.00	1.28	0.78
ORION	-	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.01	1.00	1.00	1.01	0.99
PHARMAAIDS	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CENTRAL	-	1.00	1.00	1.00	0.99	1.01	1.00	1.00	1.00	0.97	1.00	1.01	0.97
ACI	-	1.00	1.00	1.00	0.99	1.01	1.00	0.60	1.66	1.00	1.03	1.66	0.60
ACME	-	1.00	1.00	1.44	1.00	1.00	1.00	1.00	1.00	1.00	1.05	1.44	1.00
Mean	-	1.00	0.97	1.07	0.98	1.03	0.96	1.01	1.06	0.99	1.01	1.20	0.88
Max.	-	1.00	1.00	1.44	1.00	1.28	1.00	1.35	1.66	1.00	1.05	1.66	1.00
Min.	-	0.99	0.86	1.00	0.78	1.00	0.74	0.60	1.00	0.97	1.00	1.00	0.60

Source: Authors' calculations based on data from annual reports of selected companies

The mean change in pure efficiency reveals that ACME's most significant increase is 5 per cent. Conversely, the maximum decrease is observed in SQUARE, BEXIMCO, AMBEE, RENATA, IBN SINA, ORION, PHARMAAIDS, and CENTRAL, where no change occurred, as reflected by a 0 per cent change. The mean pure efficiency change for the other two companies during the study period is BEACON (1 per cent) and ACI (3 per cent). Year-wise changes in mean pure efficiency show no change for 2015, -3 per cent for 2016, 7 per cent for 2017, -2 per cent for 2018, 3 per cent for 2019, -4 per cent for 2020, 1 per cent for 2021, 6 per cent for 2022, and -1 per cent for 2023. Overall, the sample experienced a positive change of 1 per cent during the study period.

4.4 Scale Efficiency Changes

Table 4 compares how scale efficiency evolved across the selected pharmaceutical companies during the study period. A decision-making unit is considered scale efficient when it operates at an optimal production level, such that any increase or decrease in its scale of operations would reduce overall efficiency. In this context, the highest observed change is in ACI (5497 per cent) for 2022, followed by AMBEE (164 per cent) in 2021, BEACON (144 per cent) in 2021, BEXIMCO (143 per cent) in 2021, SQUARE (119 per cent) in 2021, IBN SINA (47 per cent) in 2020, PHARMAAIDS (37 per cent) in 2017, ORION (23 per cent) in 2020, ACME (17 per cent) in 2015, CENTRAL (11 per cent) in 2018, and RENATA (10 per cent) in 2022. The most significant decline is observed in ACI, with a 98 per cent decrease in 2021, while the smallest drop is recorded for ACME, with a 5 per cent decrease in 2022.

Table 4: Comparative scale efficiency changes in the selected PHCs

Companies	Year										Mean	Max.	Min.
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023			
SQUARE	-	1.13	0.88	1.14	1.00	1.00	0.46	2.19	1.00	1.00	1.09	2.19	0.46
BEXIMCO	-	1.14	0.89	1.13	1.00	1.00	0.41	2.43	1.00	0.97	1.11	2.43	0.41
BEACON	-	1.00	1.00	1.01	1.00	1.00	0.37	2.44	1.10	1.00	1.10	2.44	0.37
AMBEE	-	1.00	1.00	1.00	1.00	1.00	0.35	2.64	1.05	0.98	1.11	2.64	0.35
RENATA	-	1.00	1.00	1.00	0.96	1.04	1.00	0.91	1.10	1.00	1.00	1.10	0.91
IBN SINA	-	1.01	1.01	1.00	0.99	0.69	1.47	0.91	1.10	1.00	1.02	1.47	0.69
ORION	-	1.00	0.90	1.12	1.00	0.80	1.23	0.89	1.14	1.00	1.01	1.23	0.80
PHARMAAIDS	-	1.00	0.63	1.37	1.15	1.00	0.99	0.97	1.04	1.00	1.02	1.37	0.63
CENTRAL	-	1.00	1.00	0.90	1.11	1.00	1.00	0.96	1.04	1.00	1.00	1.11	0.90
ACI	-	1.00	1.00	0.92	1.09	1.00	1.00	0.02	55.97	1.00	7.00	55.97	0.02
ACME	-	1.17	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.07	1.02	1.17	0.95
Mean	-	1.04	0.94	1.05	1.03	0.96	0.84	1.40	6.04	1.00	1.59	6.65	0.59
Max.	-	1.17	1.01	1.37	1.15	1.04	1.47	2.64	55.97	1.07	7.00	55.97	0.95
Min.	-	1.00	0.63	0.90	0.96	0.69	0.35	0.02	0.95	0.97	1.00	1.10	0.02

Source: Authors' calculations based on data from annual reports of selected companies

The mean change in scale efficiency indicates that the highest increase was observed in ACI, with a 600 per cent improvement. Conversely, RENATA and CENTRAL show a 0 per cent change, indicating no improvement during the study period. The change in mean scale efficiency for the remaining eight companies was: SQUARE (9 per cent), BEXIMCO (11 per cent), BEACON (10 per cent), AMBEE (11 per cent), IBN SINA (2 per cent), and ACME (2 per cent). The year-wise changes in mean scale efficiency reveal an increase of 4 per cent in 2015, a decline of 6 per cent in 2016, an increase of 5 per cent in 2017, 3 per cent in 2018, a decrease of 4 per cent in 2019, a significant drop of 16 per cent in 2020, followed by a notable rise of 40 per cent in 2021 and a substantial increase of 504 per cent in 2022, while no change was recorded in 2023. Overall, the sample exhibited a cumulative positive change of 59 per cent over the study period.

4.5 Total Factor Productivity Changes

Table 5 shows comparative changes in total factor productivity (TFP) of the selected pharmaceutical industries over the study period. Total Factor Productivity (TFP) captures the residual growth in a firm's, industry's, or economy's total output that cannot be attributed solely to the accumulation of conventional inputs such as labour and capital. In essence, TFP measures the efficiency of all inputs in the production process. In this context, the highest increase in TFP was observed in ACI, with a remarkable change of 6,355 per cent in 2022. This was followed by PHARMAAIDS (1,435 per cent) in 2019, IBN SINA (585 per cent) in 2020, ORION (360 per cent) in 2020, CENTRAL (291 per cent) in 2020, ACME (278 per cent) in 2020, BEACON (144 per cent) in 2021, AMBEE (128 per cent) in 2021, SQUARE (123 per cent) in 2022, RENATA (115 per cent) in 2020, and BEXIMCO (81 per cent) in 2021. ACI recorded the most significant decline in TFP with a 99 per cent decrease in 2021, while the smallest drop was 14 per cent for ACME in the same year.

Table 5: Comparative total factor productivity changes in the selected PHCs

Companies	Year										Mean	Max.	Min.
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023			
SQUARE	-	0.65	0.98	1.34	0.54	0.87	0.53	1.64	2.23	0.07	0.98	2.23	0.07
BEXIMCO	-	0.59	1.08	1.25	0.58	0.92	0.49	1.81	0.59	0.32	0.85	1.81	0.32
BEACON	-	0.47	1.23	1.14	0.52	0.94	0.33	2.44	0.42	0.84	0.92	2.44	0.33
AMBEE	-	0.42	1.60	1.05	0.50	1.00	0.34	2.28	0.73	0.70	0.96	2.28	0.34
RENATA	-	0.40	1.48	1.50	0.33	1.07	2.15	0.65	0.90	0.69	1.02	2.15	0.33
IBN SINA	-	0.43	1.39	1.28	0.29	1.33	6.85	0.63	0.88	0.78	1.54	6.85	0.29
ORION	-	0.43	1.10	1.41	0.52	1.02	4.60	0.64	0.92	0.90	1.28	4.60	0.43
PHARMAAIDS	-	0.44	0.84	1.67	1.24	15.35	0.12	0.69	0.94	0.96	2.47	15.35	0.12
CENTRAL	-	0.43	2.61	1.11	1.17	1.68	3.91	0.70	0.94	0.89	1.49	3.91	0.43
ACI	-	0.44	2.84	1.21	1.20	1.73	3.75	0.01	64.55	0.90	8.51	64.55	0.01
ACME	-	1.24	2.63	1.44	1.18	1.67	3.78	0.86	0.87	0.97	1.63	3.78	0.86
Mean	-	0.54	1.62	1.31	0.73	2.51	2.44	1.12	6.72	0.73	1.97	10.00	0.32
Max.	-	1.24	2.84	1.67	1.24	15.35	6.85	2.44	64.55	0.97	8.51	64.55	0.86
Min.	-	0.40	0.84	1.05	0.29	0.87	0.12	0.01	0.42	0.07	0.85	1.81	0.01

Source: Authors' calculations based on data from annual reports of selected companies

The mean of TFP change shows the maximum change was 751 per cent in ACI. Conversely, the most significant decline is observed in BEXIMCO by 15 per cent. The change in mean TFP for the remaining nine companies is SQUARE (-2 per cent), BEACON (-8 per cent), AMBEE (-4 per cent), RENATA (2 per cent), IBN SINA (54 per cent), ORION (28 per cent), PHARMAAIDS (147 per cent), CENTRAL (49 per cent), and ACME (63 per cent) during the study period. The year-wise change of the mean TFP is -46 per cent for 2015, 62 per cent for 2016, 31 per cent for 2017, -27 per cent for 2018, 151 per cent for 2019, 144 per cent for 2020, 12 per cent for 2021, 572 per cent for 2022, and -27 per cent for 2023. However, an overall positive change of 97 per cent was explored for the sample period.

4.6 Malmquist Indices Summary for the Study Period

Table 6 illustrates the year-wise changes in the positions of Effch (Technical Efficiency Change), Techch (Technological Change), Pech (Pure or Managerial Efficiency Change), Sech (Scale Efficiency Change), and Tfpch (Total Factor Productivity Change). Tfpch maintained a position greater than 1 for five years: 2016, 2017, 2019, 2020, and 2022. However, during the remaining four years, this was not the case, primarily due to the significant decline in Techch by 51.10 per cent in 2015. Additionally, in 2018, 2021, and 2023, all components of Tfpch in 2018, except Effch in 2018 and 2023, and Sech, experienced a decrease. The highest Tfpch value, 48.90 per cent, occurred in 2019, when all Tfpch components were positive, except Effch and Sech, which saw an increase in Techch and Pech. In 2015, Tfpch experienced a negative change of 49.3 per cent, primarily due to a significant decline in Techch by 51.1 per cent, despite positive changes in both Effch and Sech. In 2016, Tfpch showed a positive change of 48.80 per cent, driven by a significant increase in Techch by 64.80 per cent, despite negative changes in Effch, Pech, and Sech. In 2017, Tfpch also experienced a positive change of 29.5 per cent due to an increase in Techch by 19.90 per cent. There was also a positive change in Effch, Pech, and Sech. In 2018, there was a 35.20

per cent negative change in Tfpch due to a heavy decrease of Techch by 35.4 per cent, though there was a positive change in both Effch and Sech. In 2020, Tfpch also experienced a positive change of 25.9 per cent due to a heavy increase in Techch by 74.20 per cent, though there was an adverse change in Effch, Pech and Sech. In 2021, there was a 31 per cent negative change in Tfpch due to a decrease in Effch, Techch, Pech and Sech, respectively.

In 2022, Tfpch also held a positive change of 27.50 per cent due to a weighty increase in Effch by 58.10 per cent and Sech by 50.60 per cent, though there was a negative change of Techch by 19.30 per cent. In 2023, there was a 38.30 per cent negative change of Tfpch due to a heavy decrease of Techch by 38 per cent, and also Effch and Pech, though there was a positive change of both Sech by 0.20 per cent. The maximum Effch change is 58.10 per cent in 2022 because Sech increased by 50.60 per cent. Effch enjoyed more than 1 for 4 years, whereas the other 5 years did not. When considering the mean value, Tfpch disclosed a positive change of 2.9 per cent because all the components of Tfpch showed a positive change. Effch enjoyed an average positive increase of 2.3 per cent, Techch by 4.8 per cent and Sech by 2 per cent.

Table 6: Malmquist indices summary of annual mean of the selected companies

Year	Effch	Techch	Pech	Sech	Tfpch
2014	-	-	-	-	-
2015	1.038	0.489	0.999	1.039	0.507
2016	0.900	1.648	0.970	0.929	1.484
2017	1.080	1.199	1.032	1.047	1.295
2018	1.002	0.646	0.977	1.026	0.648
2019	0.974	1.529	1.024	0.951	1.489
2020	0.723	1.742	0.960	0.753	1.259
2021	0.917	0.753	0.992	0.924	0.690
2022	1.581	0.807	1.050	1.506	1.275
2023	0.995	0.620	0.994	1.002	0.617
Mean	1.023	1.048	1.000	1.020	1.029
Max.	1.581	1.742	1.050	1.506	1.489
Min.	0.723	0.489	0.960	0.753	0.507

Source: Authors' calculations based on data from annual reports of selected companies

4.7 Malmquist Indices Summary for the Selected Companies

Table 7 presents the company-wise variations in Effch, Techch, Pech, Sech, and Tfpch positions. Tfpch is greater than 1 for 3 companies (CENTRAL, ACI and ACME) out of 11 selected companies. Techch's efficiency in the company SQUARE decreased by 28.60 per cent, which is responsible for the negative growth of Tfpch during the study period. The maximum Tfpch is 42.50 per cent for the company ACME, where 40 per cent Techch and 1.80 per cent Effch and Sech played a positive Tfpch. For company SQUARE, Tfpch holds negative change by 27.60 per cent, where a 28.60 per cent decrease in Techch was offset by a 1.40 per cent increase in Effch and Sech, respectively. For BEXIMCO, Tfpch holds

negative change by 25.40 per cent, whereas a 26.30 per cent decrease in Techch was offset by a 1.10 per cent increase in both Effch and Sech. For BEACON, Tfpch holds negative change by 23.60 per cent, whereas a 23.06 per cent decrease in Techch. For AMBEE, Tfpch holds negative change by 19.50 per cent, whereas a 0.6 per cent, 19 per cent, .1 per cent and 0.4 per cent decrease in Effch, Techch, Pech and Sech. For the company RENETA, Tfpch holds a negative change of 13.5 per cent, whereas Techch holds a 13.5 per cent decrease. For IBN SINA, Tfpch shows a negative change of 1.5%, driven by declines of 1.4% in Techch, 0.1% in Effch, and 0.3% in Pech, partially balanced by a 0.2% improvement in Sech. Tfpch experienced a negative change of 1.6 per cent for the ORION company, whereas Techch experienced a 1.6 per cent decrease. For the company PHARMAAIDS, Tfpch experienced a negative change of 1.8 per cent, whereas Techch experienced a 1.8 per cent decrease. For company CENTRAL, Tfpch holds positive change by 20.9 per cent, where a 0.3 per cent decrease in Effch and a 0.3 per cent decrease in Pech is offset a 21.3 per cent increase in Techch. For company ACI, Tfpch holds positive change by 23.8 per cent, whereas Techch has a 23.8 per cent increase.

Table 7: Malmquist indices summary of firm mean of selected companies

Companies	Effch	Techch	Pech	Sech	Tfpch
SQUARE	1.014	0.714	1.000	1.014	0.724
BEXIMCO	1.011	0.737	1.000	1.011	0.746
BEACON	1.000	0.764	1.000	1.000	0.764
AMBEE	0.994	0.810	0.999	0.996	0.805
RENATA	1.000	0.865	1.000	1.000	0.865
IBN SINA	0.999	0.986	0.997	1.002	0.985
ORION	1.000	0.984	1.000	1.000	0.984
PHARMAAIDS	1.000	0.982	1.000	1.000	0.982
CENTRAL	0.997	1.213	0.997	1.000	1.209
ACI	1.000	1.238	1.000	1.000	1.238
ACME	1.018	1.400	1.000	1.018	1.425
Mean	1.003	0.972	0.999	1.004	0.975
Max.	1.018	1.400	1.000	1.018	1.425
Min.	0.994	0.714	0.997	0.996	0.724

Source: Authors' calculations based on data from annual reports of selected companies

The maximum Effch changes is 1.8 per cent for the company ACME because of the increase of Sech by 1.8 per cent. For the companies SQUARE and BEXIMCO, Effch, change was found at 1.4 and 1.1 per cent because of an increase in Sech by 1.4 and 1.1 per cent, respectively. For the companies, AMBEE, IBN SINA and CENTRAL showed Effch 0.6 per cent, 0.1 per cent and 0.3 per cent negative changes, respectively. The Effch for BEACON, RENETA, ORION, PHARMAAIDS, and ACI showed no change, i.e., 1.0 over the study period. Looking at the average value, Effch holds a favourable position (0.3 per cent) due to the positive contribution of Sech (0.4 per cent). Tfpch has a value less than 1.00 indicated; mean Tfpch decreases by 2.5 per cent with a positive change of Effch by 0.3 per cent and a negative shift in Techch by 2.8 per cent.

5. Conclusion

The study on the efficiency changes of pharmaceutical companies in Bangladesh from 2014 to 2023 using the Malmquist indices has revealed significant insights into the overall industry performance. The study finds that the cost of goods sold, share capital, total liability, operating expense, and total assets are significant variables that influence the pharmaceutical industry's performance in terms of gross profit. The analysis of technical efficiency changes, technological efficiency changes, pure efficiency changes, scale efficiency changes, and TFP changes reveals that the overall positive changes are 97 per cent, 28 per cent, 1 per cent, 59 per cent, and 97 per cent, respectively. These findings highlight the potential for the pharmaceutical industry in Bangladesh and its peer countries to enhance its efficiency and global competitiveness. By addressing the identified rooms for improvement, pharmaceutical companies can maximize outputs with minimal inputs, ultimately leading to increased profitability and foreign currency earnings by exporting quality healthcare needs. However, the present study has its limitations. It examines only 11 pharmaceutical companies in Bangladesh, which may not accurately reflect the broader industry's performance. The analysis also relies on 10 years of data, which may not be enough to capture long-term efficiency patterns. Moreover, only a few input and output variables were used, which may have limited the depth of the efficiency evaluation. Future studies could improve on this by including more companies and covering a longer period to gain a clearer picture of industry trends. Using a wider set of input and output variables could also lead to more precise results. Additionally, applying other efficiency measurement methods in conjunction with the Malmquist Index could provide more comprehensive and comparative insights.

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