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TOTAL FACTOR PRODUCTIVITY AND EFFICIENCY OF BANGLADESH PHARMACEUTICAL INDUSTRY

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The Graduate School of Hansung University

Major in International Market Analysis

Dept. of International Trade and Economics

Islam Md Samimul

Master Thesis
Advisor Professor Jaewhak Roh

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- 방글라데시 제약 산업의 총 요소 생산성 및 효율성-

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Abstract

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With an annual two-digit growth rate, Bangladesh's pharmaceutical industry is currently able to satisfy about 97 percent of all domestic demand. But the question of how well the corporations produce is raised. The study employs Data Envelopment Analysis (DEA) to gauge the technological efficiency of Bangladesh's pharmaceutical sector from 2011 to 2021. With one output annual sales and four inputs 1. fixed asset cost, 2. raw material cost, 3. Electricity and gas and 4. salary cost. we employ the non-parametric DEA. The analysis's findings show that the Malmquist total factor productivity index (TFPCH), which has a value of 5.2 percent yearly, has maintained a slightly increasing trend throughout the study period. Additionally, with a value of 10.8% positive increase per year, technical progress has been found to be the main driver of TFPCH growth. Furthermore, with values of 5.1 percent, 3.1 percent, and 345 percent, respectively, all changes in technical efficiency, pure efficiency, and scale efficiency have regressed.

Due to technical advancement and an overall decline in efficiency, productivity as a whole increased. Thus, rather than increased efficiency, the increases in productivity are solely the result of technological breakthroughs. Instead of pure technical inefficiency, scale inefficiency is the primary cause of inefficiency in the pharmaceutical sector. There have two type of company bulk drug manufacturers and bulk drug and formulation drug both manufacturers. Among them bulk drug manufacturers show better efficiency than other.

【Keyword】: Data Envelopment Analysis. Efficiency, Malmquist, Productivity, Bulk Drug, Formulation Drug

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Chapter 1 Introduction

Bangladesh's pharmaceutical industry is one of the country's most advanced technological sectors. Insulin, hormones, and cancer treatments are all made by manufacturers. This industry meets 97 percent of the local market's entire medicinal needs. Medicines are also exported to other markets, particularly Europe. Pharmaceutical businesses are expanding their operations in order to increase their export market share. Since the early 1980s, Bangladesh's pharmaceutical industry has been changing and evolving. Over the previous four decades, the industry has developed from strength to strength. The road was not simple for an LDC country facing significant economic issues because this is a technology and knowledge-based business. Bangladesh now boasts the distinction of being the only LDC with a well-developed pharmaceutical industry. The industry has a significant research focus on generic formulation development, and it has already demonstrated its ability to generate specialized, high-tech formulations that are difficult to duplicate. To differentiate themselves, leading companies have focused on specialized dosage delivery systems, such as the metered dose inhaler (MDI), dry powder inhaler (DPI), lyophilized injectables, sterile ophthalmics, prefilled syringes, oral thin films, multi-layer tablets, and biological products such as insulin and vaccines. Bangladesh's pharmaceutical industry total market size approx. US $2.42 billion. Historically good growth maintained 10-15% last few years. It's had strong manufacturing base; skilled manpower, Largest white collar labour intensive employment sector. 2nd highest contributor to national exchequer. Bangladesh has 257 registered companies around 150 are functional. All the top 10 companies are local and they have approx. 70% market share. Here I use total factor productivity analysis. By total factor productivity we can see measure of

productive efficiency in that it measures how much output can be produced from a certain number of inputs. We can see best performing companies and can find out the gap of comparatively fewer performing companies.

In the 1950s, a few MNCs and local businesses launched Bangladesh's pharmaceutical sector. Bangladesh was granted patent exemption in the pharmaceutical sector after attaining independence in 1971 as a least developed nation under the British Patents and Designs Act of 1911. As a result, the nation's output of generic medications started to rise. However, the 1980s saw the start of the pharmaceutical industry's expansion. Bangladesh has 166 pharmaceutical manufacturers with licenses in 1981. However, eight international corporations, including Glaxo, Pfizer, and Hoechst, accounted for 75% of the nation's pharmaceutical manufacturing at the time. At the time, 133 firms produced the remaining 10%, while 25 medium-sized local pharmaceutical companies contributed 15%. All of these businesses formerly produced pharmaceuticals locally using raw materials that were annually imported for BDT 60 crore in foreign currency. Despite the presence of 16 domestic pharmaceutical firms, 30 crore BDT worth of medications are imported annually.

Bangladesh's pharmaceutical value chain is essentially split into two sections. Active pharmaceutical ingredients, sometimes known as APIs, and finished formulation make up the first. In its simplest form, API refers to medications with particular active components for certain disorders. On the other hand, finished formulation essentially refers to the medication created by combining several compounds with active ingredients.

The government established an expert committee to create a drug strategy in March 1982. The group develops regulations for both the API industry

and the formulations industry. Two other new rules were adopted in June, although the previous administration only permitted the issuing of the Drugs (Control) Ordinance for the formulations industry. One was to outlaw the production, import, and distribution of hazardous and needless pharmaceuticals, and the other was to outlaw MNC items that were produced outside of the nation's borders. Bangladesh did not remove any of the regulations, despite pressure from the US government at the time, according to a research by Sudip Chaudhuri titled EVOLUTION OF THE PHARMACEUTICAL INDUSTRY IN BANGLADESH. Out of the 4340 registered drugs at the time, however, around 1700 were prohibited and taken off the market. MNCs were given the opportunity to rearrange their activities as a result, although other businesses—including Squibb—were forced to cease operations in Bangladesh. Bangladesh joined the World Trade Organization in 1995 and signed the TRIPS agreement. Bangladesh benefited from the ability to produce and commercialize medications without a patent because it is one of the least developed nations. Due to lower production costs, Bangladesh is able to produce pharmaceuticals at considerably lower consumer prices, which is crucial for a country with a developing healthcare system like Bangladesh. The agreement was initially only in effect through 2005, however it was later extended to 2016. Later, until 2033, this arrangement was again extended. The development of the nation's pharmaceutical industry is accelerated by this facility.

With a market value of around 3 billion, Bangladesh's pharmaceutical business currently provides 1.83 percent of the GDP of the nation. There are currently 257 approved pharmaceutical manufacturers in Bangladesh, according to a report by the Directorate General of Drug Administration (DGDA). From there, 150 plants are still running normally, satiating around 98% of the nation's overall demand. Currently, local

manufacturers control 90% of the nation's overall pharmaceutical market, while multinational institutions control the remaining 10%. Currently, Bangladesh produces more than 450 generic pharmaceuticals for 5,300 recognized brands and 4% of the nation's anti-cancer treatment needs. Approximately 80% of the pharmaceuticals now produced in Bangladesh are generic medicines, with the remaining 20% being proprietary medicines.

The pharmaceutical sector in Bangladesh has increased annually at a CAGR of 15.6% during the last five years. The Bangladeshi pharmaceutical market was worth about $2.42 billion in 2018, and it will be about $3 billion in 2019. The pharmaceutical market size will increase by 114 percent and reach more than 6 billion dollars by the year 2025, predicts ResearchAndMarkets. Additionally, Bangladesh was able to make 136 million dollars in the 2019-20 fiscal year by selling medications to 147 other nations. Currently, Bangladesh's pharmaceutical sector is attempting to take 10% of the global pharmaceutical market. The World Health Organization (WHO), the World Trade Organization (WTO), and the World Intellectual Property Organization (WIPO) have already granted authorization to six national organizations.

As some of the leading participants in Bangladesh's pharmaceutical business, names like Square, Beximco, and Incepta must come to mind. With a roughly 16 percent revenue market share, Square Pharmaceuticals holds the top spot in the pharmaceutical sector. With a market share of 10.21 percent, Incepta is in second place, followed by Beximco (8.39 percent) and Opsonin (5.54 percent). Beximco Pharmaceuticals earned 32.46 million from exports in the 2018-19 fiscal year, and Square Pharmaceuticals made 19 million from exports during the same period. Square Pharmaceuticals has expanded internationally by locating its

manufacturing facility in Kenya.

Exports and domestic sales account for the majority of the pharmaceutical sector's income in Bangladesh. The pharmaceutical sector in Bangladesh is now growing in terms of income for a number of reasons.

Bangladesh currently has a population of about 166 million people, and it is expanding at an average rate of 1.1 percent each year. Additionally, The Business Standard reported that Bangladesh today has more than 37 million middle-class families. It accounts for around 22% of the nation's overall population and is continually increasing. Bangladesh's per capita income climbed to $2,227 USD in the fiscal year 2020-21, up 8% over the previous year. In addition to an increase in the population of middle- and upper-class Bangladeshis, the nation's overall consumption is also on the rise. The price of medical care for the nation's population has increased as a result.

People's awareness of their health has increased both in urban and rural areas as a result of rising economic levels. People in the country are paying particular attention to good nutrition, protein intake, healthy eating habits, and avoiding other contaminants as the country's medical and pharmaceutical firms implement current technology. In addition, the average life expectancy of Bangladeshis has grown. The average life expectancy of Bangladeshis was 66.4 years in 2002, and it would rise to 72.6 years by 2020, according to the Bangladesh Bureau of Statistics. The rise in the pharmaceutical industry and public awareness of Bangladeshi citizens have been the main drivers of this rise in life expectancy.

More than 1,200 pharmaceutical items have been registered for export in Bangladesh over the past two years, claims the Bangladesh Association of Pharmaceutical Industries (BAPI). According to the Bangladesh Export

Promotion Bureau, during the 2018–19 fiscal year, Bangladesh shipped medications to 147 different countries, with 60.32 percent of those exports going to Myanmar, Sri Lanka, the Philippines, Vietnam, Afghanistan, Kenya, and Slovenia. The industrialized nations like the US, Canada, Germany, and Australia, receiving the remaining 39.6%. Bangladesh exported medications worth 130 million USD in FY 2018–19, and 136 million USD in FY 2019–20. Bangladesh's pharmaceutical exports doubled between 2014–15 and 2019–20 at an average pace of nearly 12% each year. Bangladesh's exports are expected to reach 450 million dollars by 2025, predicts ResearchAndMarkets.

According to the TRIPS agreement with the World Trade Organization, Bangladesh would receive patent exemption on pharmaceutical items until 2033 as a least developed country. However, Bangladesh is expected to lose the patent exemption facility 7 years before the expiration date because it plans to leave the LDC category by 2026. Which might halt Bangladesh's pharmaceutical industry's growth since, should Bangladesh lose the TRIPS agreement's benefits, new patent regulations would need to be enacted. As a result, it is likely that many different generic drug types will no longer be manufactured. Domestic pharmaceutical producers may need to pay royalties on patents in order to keep making these medications. As a result, Bangladeshi prescription drug prices could rise generally. If not, businesses risk being charged for violating patents, and exports will be seriously restricted. The fact that Bangladesh's pharmaceutical businesses give little attention to research is one of the industry's main problems. As a result, the indigenous pharmaceutical industry lacks innovation. In addition to this, subpar and counterfeit medications pose a serious danger to Bangladesh's pharmaceutical industry. Despite rigorous regulations governing the quality of pharmaceuticals supplied overseas, the local market is flooded with fake

medications. Quality producers thus lose a lot of dividends every year. Additionally, the majority of the raw materials used to make medications must be imported from abroad; however, if these resources were produced domestically, the pharmaceutical sector would be able to become more self-sufficient and production costs might be further decreased. The pharmaceutical industry in Bangladesh is one of the areas of the economy that is evolving. Bangladesh exports a lot of goods, which helps the nation gain foreign currency in addition to supplying the demand for medications. It is hoped that if Bangladesh can maintain this growth, the pharmaceutical industry's contribution to GDP will rise even higher in the future, despite its relatively tiny current share in the GDP of the nation. Bangladesh needs to alter its policies,

Chapter 2 Literature Review

The first of its kind would be the measuring of efficiency in the Bangladeshi pharmaceutical industry. Past research has largely focused on the pharmaceutical industry, and has looked at many aspects of production such as input, output, restrictions, and so on. The majority of manufacturing literature has concentrated on output-oriented productivity, such as sales. A unit improvement in input efficiency corresponds to a unit increase in output. As a result, lower input costs may be offset by greater output levels. Only the literature on efficiency, productivity in the pharmaceutical and manufacturing industries, and Total Factor Productivity is included in this article.

Both Azam and Richardson (2010) and Royhan (2013) The focus was on the current state and prospects of Bangladesh's pharmaceutical sector. Their findings are limited in their ability to properly justify the growth statement and model definition. Saranga and Phani (2004) examined Data from 44 publicly traded Indian pharmaceutical businesses was used to create a DEA of Indian pharmaceutical companies. The authors argued that a company's internal efficiency had little bearing on its growth. They recommended that a preparation be a "product patent" rather than a "process patent." They believe that a more advanced understanding of the global scenario in the pharmaceutical business, as well as an action plan, can save the entire industry in the event of a significant external economic and international crisis. Mazumdar and Rajeev (2009) compared the efficiency of various Indian pharmaceutical firms. They looked at data from 2492 imbalanced businesses from 1991 to 2005. Positive technical efficiency changes have been documented in enterprises with large-scale and import-oriented new innovation, according to the study. Investment

in R&D was shown to be a low contributor to Total Factor of Productivity Growth across the organizations studied. Kirigia, Emrouznejad, Sambo, Munguti, and Liambila (2004) investigated the technical efficiency of Kenyan health care institutions. DEA has been investigated using secondary data from 32 major health care centers. According to their findings, 44 percent of all health-care facilities are technically inefficient. Using the same technique, Hashimoto and Haneda (2008) looked at the technological efficiency of the Japanese pharmaceutical sector. They employed a single output, sales volume, as well as three inputs: patent or R&D, product innovation, and process innovation cost. Their findings were characterized as a persistent negative productivity decline from 1982 to 2001. Tripathy, Yadav, and Sharma (2013) used the Malmquist productivity index to study 81 Indian pharmaceutical companies. Over the course of the study, a positive change in technical efficiency was noted. The study yielded significant results in finding firm-specific productivity parameters for any pharmaceutical firm. Age of establishment, R&D, ownership, and foreign direct investment are only a few examples. Nordin Haji Mohamad and Said (2011) used data from 2003 to 2008 to assess the effectiveness of government-linked Malaysian businesses. Only ten companies were found in the favorable border by DEA analysis. Even though the companies showed a favorable technical efficiency improvement in their results, the Malmquist index of TFPCH analyzed that they did not attain recommending technological change of new innovations and advancement. Paid-up capital, fixed assets, and total salary were utilized as inputs, whereas sales income, return on asset, and market price per share were used as outputs. Ramli and Munisamy (2013) contributed to the existing literature with their latest work on technical and ecological efficiency. Between 2001 and 2010, they used DEA and the Directional Distance

Function (DDF) on manufacturing industries. Operating expenses and capital were used as inputs, with sales as the desired result. Only the best-practiced enterprises can embrace and make use of new technological adoption at a faster pace than others, according to Noordin Haji Mohamad and Said's (2012) study on efficiency measurement of 42 world economies on the effect of technology innovation. TFPCH decomposition also revealed that efficiency changes were not significantly different from technological innovation in the economy. According to the authors, a positive unit TFPCH change can increase output and shift the economy to a higher frontier. Schiersch (2012) studied more than 22,023 observations of the German mechanical engineering industry to bridge the gap in the size-efficiency relationship. According to the findings, small and large businesses are more efficient than medium-sized businesses. Their findings also revealed that in the case of size-efficiency relationships, a U-shaped link has been detected, as opposed to the simple increasing form identified in previous studies. A large number of studies have used DEA to measure TFPCH growth all around the world. From 1981 to 1996, Mahadevan (2002) examined the TFPCH of Malaysian manufacturing industry. Technical efficiency and scale efficiency were examined, and a positive growth rate of 0.8 percent per year was discovered. According to the literature, technical advancements are to blame for this unsatisfactory change. Din, Ghani, and Mahmood (2007) looked at how efficient Pakistan's large-scale manufacturing industry is. Both parametric and non-parametric frontier approaches were used. They looked examined data from 1995 to 2001. In both cases, there was just a minor boost in efficiency. Capital and labor were employed as inputs, and industrial and non-industrial costs were used as outputs. Non-industrial expenses include intangible and non-operational costs, while industrial costs explain operating costs. In the calculation of Total

Factor Productivity increase for efficiency measurement, a growing worry has been identified over time. Technology and innovation, according to Kartz (1969), play a substantial effect in productivity changes. His research studied TFPCH in Argentina from 1946 to 1961 and found an increase in labor productivity in the industrial sector. Jajri and Ismail (2007) used the Data Envelopment Analysis (DEA) technique to calculate the efficiency of the Malaysian manufacturing sector from 1985 to 2000, utilizing two inputs: labor and capital expenditure (Fixed Asset), and a single output: value added sales price. According to their findings, technical efficiency is the most important factor in Total Factor Productivity. Except in the textile industry, there was an upward tendency in technical change. The majority of empirical studies on efficiency management have found that the pharmaceutical industry's efficiency is positively related to scale, strong governance, technical innovation, and the nature of the business (Anesary et al., 2014; Mazumdar & Rajeev, 2009; Saranga & Phani, 2004). There is a poor association between geographical region, analytic model, time frame, and efficiency (Azam & Richardson, 2010; Centre, 2007; Hossain et al., 2014). As a result, the current study aims to investigate the case of Bangladesh's pharmaceutical industry.

Chapter 3 Methodology

In this study, we apply the data envelopment analysis (DEA) method to calculate the productivity of Bangladesh's pharmaceutical industry. Farrell (1957) was the first to introduce DEA, while Charnes et al. (1978) established the practical approach. This method constructs a piece-wise linear surface or the best practice frontier over the given data using the inputs and outputs of decision-making units (DMU). For each DMU, the frontier is formed by solving a series of linear programming problems. Input-oriented DEA and output-oriented DEA are two different types of DEA. The input-oriented DEA approach aims for the greatest proportional decrease in input usages over the collection of outputs available. The output-oriented DEA method, on the other hand, seeks the greatest proportional increase in output production from a given set of inputs. When using constant return to scale (CRS) technology, these two measurements yield the same outcome in terms of technical efficiency score. According to Coelli and Rao, (2005) we employed an output-oriented DEA model wi Data envelopment analysis

The relative effectiveness of numerous related entities or DMUs is objectively quantified using the linear programming methodology known as DEA (Cooper et al., 2007). The conversion of inputs into outputs is carried out by the homogenous DMU. A matrix made up of the inputs, outputs, and complementary components of the sample of DMUs is needed to conduct a DEA analysis. The matrix is applied in the model to be solved after the DEA model has been constructed according to a set of features including metrics and orientation. As a result, the major outcomes are relative efficiency scores and operational benchmarks for each DMU.

Based solely on the observable data and fundamental presumptions for the resolution of an optimization model, the relative efficiency scores are computed using a nonparametric technique. An efficiency score (ϕ) is calculated for each DMU. Additionally, a set of goal values (i.e., benchmarks) that would turn the DMUs identified as inefficient (i.e.$\phi > 1$) into efficient are computed for those DMUs. As a result, DEA promotes doable enhancements for an efficient operational performance while allowing distinction between efficient and wasteful organizations. The mathematical technique is based on the computation of efficiency frontiers for the set of DMUs once the matrix of observed data and the DEA model are prepared. The production possibility set is said to be defined by the efficiency frontier, which is claimed to enclose all units.

There are many different DEA models available depending on the range of needs driving each study. Model orientation (model oriented to inputs and/or outputs), model metrics (radial or nonradial), and display of the production possibility set (e.g., constant returns to scale (CRS) or variable returns to scale (VRS)) are some of the technical features that these models are constructed in accordance with (Lozano et al., 2009).

There are three different types of model orientation: input-oriented, output-oriented, and nonoriented (Cooper et al., 2007). According to an input-oriented paradigm, an inefficient entity can become efficient by lowering its inputs while maintaining at least the same level of outputs. On the other hand, under an output-oriented paradigm, the DMU is transformed into an efficient entity by increasing outputs while keeping inputs constant. An increase in outputs and a decrease in inputs are the goals of a nonoriented (or mixed) model.

Radial and nonradical models are two variations that can be distinguished based on the model metrics. The Charnes, Cooper, and

Rhodes (CCR) model, which is a representation of radial models, is based on proportionate changes in the levels of inputs or outputs (Charnes et al., 1978). Instead of handling proportional changes in inputs or outputs, nonradical models, like the slacks-based measure of efficiency (SBM) model, manage individual slacks for each input or output (Tone, 2001).

The idea of returns to scale has also received considerable attention within the various DEA frameworks. If an increase in a DMU's input levels results in an equivalent increase in output levels, the DMU is said to be operating at CRS. A model that takes VRS into account should be utilized if it is believed that this proportionate effect does not exist (Cooper et al., 2007; Lozano et al., 2009).th a constant return to scale (CRS) assumption in this investigation (2005).

3.1 Malmquist Productivity Index

Fisher index, Tornqvist index, and the Malmquist productivity index (MPI) are some of the total factor productivity (TFPCH) indices used to quantify productivity increases, with MPI being the most prominent (Casu et al., 2004), The Malmquist index, according to Grifell-Tatje & Lovell (1996), offers three distinct benefits over the Fisher and Tornqvist indices. For starters, it does not necessitate knowing the input and output prices. Second, cost minimization and revenue maximization are not assumed. Third, it can decompose productivity change into technical efficiency change (catching-up) and technological progress (changes in best practicing firm). We can show that the total factor productivity change is the product of technical efficiency change and technological change.

The change in technical efficiency is broken down into two categories:

pure technical efficiency and scale efficiency change. Scale efficiency relates to the TIB's ability to work at its optimal scale, while pure technical efficiency refers to the management skill. Its biggest drawback is the requirement to construct a distance function. The data envelopment analysis (DEA) technique, on the other hand, can be utilized to tackle this issue. The MPI is calculated by multiplying the catch-up index by the frontier shift index. The catch-up terms refer to how much a decision-making unit increases its relative efficiency, whereas the frontier-shift terms refer to how the efficient frontiers have changed between the two time periods. The MPI calculates the ratio of each era's distance from a common technological frontier to assess TFPCH change between two time periods, and it requires input and output from one time period to be blended with technology from another time period., (Rao et al., 2004).

Caves et al. (1982) established the Malmquist productivity index as a theoretical indicator, which Fare et al. popularized as an empirical index (1994a). The Malmquist productivity index is based on a benchmark technology that provides consistent returns to scale, as opposed to a best practice technology that provides variable returns to scale. As a departure of best practice technology from benchmark technology, this convention allows it to embrace the influence of scale economies. The output-oriented Malmquist productivity index is stated as using the period t benchmark technology.

$$M_{oc}^{t}\left(x^{t}, y^{t}, x^{t+1}, y^{t+1}\right) = \frac{D_{oc}^{t}\left(x^{t+1}, y^{t+1}\right)}{D_{oc}^{t}\left(x^{t}, y^{t}\right)},$$

where "$_{oc}^{t}$" denotes the period t benchmark technology on which the distance functions that make up the Malmquist productivity index are

defined. The term " $_{oc}^{t}$ " would be changed to "$_{oc}^{t+1}$" when defining a Malmquist productivity index on the period t +1 benchmark technology. It is customary to define the Malmquist productivity index as the geometric mean of the two indices because both are arbitrary and aren't necessarily equal.

$$M_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) = \{[M^t_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) \times M^{t+1}_{oc}(x^t, y^t, x^{t+1}, y^{t+1})]\}^{1/2}$$
$$= \left[\frac{D^t_{oc}(x^{t+1}, y^{t+1})}{D^t_{oc}(x^t, y^t)} \times \frac{D^{t+1}_{oc}(x^{t+1}, y^{t+1})}{D^{t+1}_{oc}(x^t, y^t)}\right]^{1/2}.$$

M_{oc} (x^t, y^t, x^{t+1}, y^{t+1}) according as productivity growth, stagnation or decline

occurs between periods t and t + 1.

An initial dissection of the index was presented by Faare et al. (1994a) as follows:

$$M_{oc}\left(x^t, y^t, x^{t+1}, y^{t+1}\right) = \left[\frac{D^{t+1}_{oc}(x^{t+1}, y^{t+1})}{D^t_{oc}(x^t, y^t)}\right] \times \left\{\left[\frac{D^t_{oc}(x^{t+1}, y^{t+1})}{D^{t+1}_{oc}(x^{t+1}, y^{t+1})} \times \frac{D^t_{oc}(x^t, y^t)}{D^{t+1}_{oc}(x^t, y^t)}\right]\right\}^{1/2}$$
$$= TE\Delta_c\left(x^t, y^t, x^{t+1}, y^{t+1}\right) \times T\Delta_c\left(x^t, y^t, x^{t+1}, y^{t+1}\right),$$

where TE (x^t, y^t, x^{t+1}, y^{t+1}) measures the change in technical efficiency and T△c (x^t, y^t, x^{t+1}, y^{t+1})the geometric mean of the technical change magnitudes along rays through (x^{t+1}, y^{t+1}) and (x^t, y^t). On the benchmark

technologies, both components are evaluated. It is desirable to redefine both components of best practice technologies in order to examine what is left over and determine whether what is left over can be given a valid economic interpretation. This is because best practice technologies may display varied returns to scale.

One component was redefined by Faare et al. (1994b). To get, they divided the technological

$$TE\Delta_c(x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right] \times \left\{\frac{\left[D_{oc}^{t+1}(x^{t+1}, y^{t+1})/D_o^{t+1}(x^{t+1}, y^{t+1})\right]}{\left[D_{oc}^t(x^t, y^t)/D_o^t(x^t, y^t)\right]}\right\}$$
$$= TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times \left[\frac{SE^{t+1}(x^{t+1}, y^{t+1})}{SE^t(x^t, y^t)}\right]$$
$$= TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times SE\Delta(x^t, y^t, x^{t+1}, y^{t+1}),$$

where SE△c (x^t, y^t, x^{t+1}, y^{t+1}) measures the change in scale efficiency from period t to period t+1 and TE△c (x^t, y^t, x^{t+1}, y^{t+1}) measures technical efficiency change on the best practice technologies (1994b). Malmquist productivity index efficiency change component breakdown.

$$M_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) = TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times SE\Delta(x^t, y^t, x^{t+1}, y^{t+1})$$
$$\times T\Delta_c(x^t, y^t, x^{t+1}, y^{t+1}).$$

Technical efficiency change $TE\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1})in this decomposition is measured in relation to best practice technologies and so corresponds to $TE\triangle_c$. Despite Freund's attempts, it is unclear how scale efficiency change $SE\triangle_c$ (x^t, y^t, x^{t+1}, yt+1)and the contribution of scale economies relate to one another (1996). Last but not least, technical change $TE\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1})is still quantified as a change in the benchmark technology and

does not, therefore, correspond to TD. The first of many to challenge this decomposition was made in 1997 by Ray and Desli. $TE\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1})can overestimate or understate the extent of technical change on the best practice technologies since the size of a shift in the benchmark technology has nothing to do with the magnitude of a shift in the best practice technology. Therefore, another element must be included in the technological change component. Thus, it must integrate the results of scale economies and technological advancement. The contribution of $SE\triangle c$ (x^t, y^t, x^{t+1}, y^{t+1}) and $TE\triangle c$ (x^t, y^t, x^{t+1}, y^{t+1})to productivity change, in my opinion, is absent from the preceding analysis. Finding it and eliminating it from $SE\triangle c$ (x^t, y^t, x^{t+1}, y^{t+1}) and $TE\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1}) are the issues. An economically significant source of productivity change is measured by the first word on the right side. The connection between the second term and the contribution of scale economies, however, is yet unclear. Additionally, the third phrase lacks an economically significant interpretation because a change in the benchmark technology does not necessarily imply or be accompanied by a corresponding change in the best practice technology. I come to the conclusion that the decomposition of the Malmquist productivity index by Fare et al. (1994b) is insufficient. By isolating $TE\triangle c$ (x^t, y^t, x^{t+1}, y^{t+1}), the change in the best practice technology, Ray and Desli made an effort to address this deficiency. To do this, they combined TE with $TE\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1}) to produce the alternate decomposition.

$$M_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) = TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times T\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times S\Delta(x^t, y^t, x^{t+1}, y^{t+1}),$$

Where,

$$TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)},$$

$$T\Delta(x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right]^{1/2},$$

and the "scale change factor"

$$\begin{aligned} &S\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \\ &= \left\{\left[\frac{D_{oc}^t(x^{t+1}, y^{t+1})/D_o^t(x^{t+1}, y^{t+1})}{D_{oc}^t(x^t, y^t)/D_o^t(x^t, y^t)}\right] \times \left[\frac{D_{oc}^{t+1}(x^{t+1}, y^{t+1})/D_o^{t+1}(x^{t+1}, y^{t+1})}{D_{oc}^{t+1}(x^t, y^t)/D_o^{t+1}(x^t, y^t)}\right]\right\}^{1/2} \\ &= \left[\frac{SE^t(x^{t+1}, y^{t+1})}{SE^t(x^t, y^t)} \times \frac{SE^{t+1}(x^{t+1}, y^{t+1})}{SE^{t+1}(x^t, y^t)}\right]^{1/2}. \end{aligned}$$

The Ray and Desli efficiency change term corresponds to TE△ since it is the same as the Faare et al. (1994b) efficiency change term. In contrast to Fare et al. (1994b), their definition of technical change is based on best-practice technologies. It consequently relates to TE△, unlike the technical change term proposed by Faare et al. (1994b). The geometric mean of two scale efficiency ratios, one measured on period t technology and the other on period t+1 technology, is their scale change factor. Therefore, the term "change" only applies to the quantity vectors and not the technologies.

Ironically, Faare et al. (1997b) were the first of many to critique the Ray and Desli decomposition since their scale change factor SE△c (x^t, y^t, x^{t+1}, y^{t+1}) cannot evaluate scale efficiency change because each component employs only a single period technology. Though economically incorrect, their criticism is sound mathematically. Returning to the geometric mean

Malmquist productivity index's original Caves et al. (1982) formulation, which may be stated and deconstructed as

$$M_o(x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \times \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right]^{1/2}$$
$$= \left[\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right] \times \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right]^{1/2}$$
$$= TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times T\Delta(x^t, y^t, x^{t+1}, y^{t+1}),$$

where the subscript "$_c$" is absent due to the fact that their index was not defined using the benchmark technology. The two productivity change factors, TE△ and T△, are correctly measured using technologies that follow best practices. Their productivity change measure, however, is incorrectly based on best practice technologies and does not match (△ ln Y− △ ln X). There is a part of the productivity change that is missing, and that part must be a scale impact. The relationship between the appropriate Caves et al. Malmquist productivity index M_{oc} (x^t, y^t, x^{t+1}, y^{t+1}) and M_o (x^t, y^t, x^{t+1}, y^{t+1} the incorrect version is given by

$$
\begin{aligned}
M_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) &= M_o(x^t, y^t, x^{t+1}, y^{t+1}) \\
&\quad \times \left\{ \left[\frac{D^t_{oc}(x^{t+1}, y^{t+1}) / D^t_o(x^{t+1}, y^{t+1})}{D^t_{oc}(x^t, y^t) / D^t_o(x^t, y^t)} \right] \right. \\
&\quad \left. \times \left[\frac{D^{t+1}_{oc}(x^{t+1}, y^{t+1}) / D^{t+1}_o(x^{t+1}, y^{t+1})}{D^{t+1}_{oc}(x^t, y^t) / D^{t+1}_o(x^t, y^t)} \right] \right\}^{1/2} \\
&= M_o(x^t, y^t, x^{t+1}, y^{t+1}) \times \left[\frac{SE^t(x^{t+1}, y^{t+1})}{SE^t(x^t, y^t)} \times \frac{SE^{t+1}(x^{t+1}, y^{t+1})}{SE^{t+1}(x^t, y^t)} \right]^{1/2} \\
&= M_o(x^t, y^t, x^{t+1}, y^{t+1}) \times S\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \\
&= TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times T\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times S\Delta(x^t, y^t, x^{t+1}, y^{t+1}).
\end{aligned}
$$

The Malmquist productivity index so breaks down into three components: technical efficiency change, technical change, and scale effect. The third component must be a scale effect. The Ray and Desli scale change factor SE△c (x^t, y^t, x^{t+1}, y^{t+1}) is exactly the third component, as shown by a comparison. Since M_{oc} (x^t, y^t, x^{t+1}, yt+1) belong to ((△ ln Y− △ ln X), and since SE△c (x^t, y^t, x^{t+1}, y^{t+1}) relate to TE△ and T△, respectively, it follows that SE△c (x^t, y^t, x^{t+1}, y^{t+1}) must correspond to the contribution of scale economies. In fact, it serves as an illustration for the M = N =1 case. I make the assumption that production is both technically and saleably efficient in both times in order to concentrate on the current problem. Because of this, the Fa et al. (1994b) decomposition credits all productivity growth to technical advancement, which is unreliably assessed as $SE\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1})〉1. The geometric mean of the vertical ratios of the two benchmark technologies, which are derived at (x^{t+1} and x^t), is how they gauge technical advancement. Their period t Malmquist productivity index underestimates the level of technical advancement, while their period (t +1) Malmquist productivity index overestimates it. These two errors' geometric mean does not always equal zero. More specifically, their technical change term averages two mistakes whose magnitudes and signs

rely on the type of scale economies over (x^t, x^{t+1}) on the two best practice technologies.

In this instance, the reality is more nuanced. There are two reasons for the increase in productivity. One is technical advancement, which Ray and Desli measure suitably as $SE\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1})〉1. The geometric mean of the vertical ratios of the two best practices technologies, which are also calculated at (x^t and x^{t+1}), is how they gauge technical advancement. The favourable impact of expansion in the face of nonconstant returns to scale on (x^t, x^{t+1}), which is also properly evaluated by Ray and Desli as

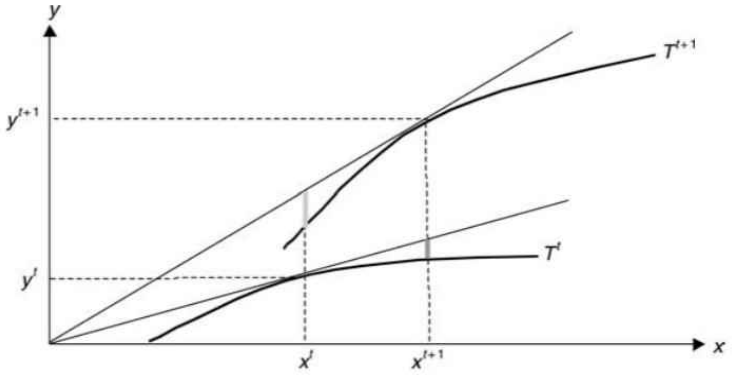

Figure 1. Technical change and scale economies in the Malmquist Productivity Index.

$SE\triangle c$ (x^t, y^t, x^{t+1}, y^{t+1})〉1. The geometric mean of significantly growing returns to scale on (T t+1) and significantly decreasing returns to scale on Tt represents the contribution of scale economies. More generally, their scale terms average two separate but theoretically sound metrics of scale economies and technical development. This interpretation of $SE\triangle c$ (x^t, y^t, x^{t+1}, y^{t+1}) includes the scenario when production is permitted to be both ethnically and scale-inefficient un both periods. Simply change

(x^t, y^t) while keeping booth's viability, and hold the best practice technologies fixed at (T^t and T^{t+1}) to show this. As input usage shifts from (x^t to x^{t+1}), SE△c (x^t, y^t, x^{t+1}, y^{t+1}) still appropriately reflects the contribution of scale economies on the two best practice technologies. Recall that scale efficiency is homogeneous of degree zero in output to confirm this. Consequently, the scale change factor might be rewritten as

$$S\Delta(x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{SE^t(x^{t+1}, y^{t+1}/D_o^t(x^{t+1}, y^{t+1}))}{SE^t(x^t, y^t/D_o^t(x^t, y^t))} \times \frac{SE^{t+1}(x^{t+1}, y^{t+1}/D_o^{t+1}(x^{t+1}, y^{t+1}))}{SE^{t+1}(x^t, y^t/D_o^{t+1}(x^t, y^t))} \right]^{1/2}.$$

An important result is that the decomposition of the Malmquist productivity index does not explicitly take scale efficiency change into account. Its function is replaced with returns to scale, which are more in line with the spirit and are defined as SE△c (x^t, y^t, x^{t+1}, y^{t+1}). I come to the conclusion that the three terms on the right side assess economically significant sources of productivity change when (M = N = 1), as the three terms on the right side match their counterparts. What if M〉1 or N〉1? In this instance, the accounting concept known as the "activity effect" or the "volume effect" is measured by the formula SE$\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1}). It incorporates a radial scale economies impact in economic terms, as well as output mix effects whenever ($y^{t+1} \neq \mu y^t$, μ〉 0) and input mix effects whenever (($x^{t+1} \neq \Lambda x^t$, Λ〉 0) The Ray and Desli scale can be easily broken down into the following components. I rename the change factor to the activity effect and recast it as AE (x^t, y^t, x^{t+1}, y^{t+1}): AE (x^t, y^t, x^{t+1}, y^{t+1}).

$$
\begin{aligned}
&AE(x^t, y^t, x^{t+1}, y^{t+1}) \\
&= \left\{ \left[\frac{D^t_{oc}(\lambda x^t, \mu y^t)/D^t_o(\lambda x^t, \mu y^t)}{D^t_{oc}(x^t, y^t)/D^t_o(x^t, y^t)} \right] \times \left[\frac{D^{t+1}_{oc}(\lambda x^t, \mu y^t)/D^{t+1}_o(\lambda x^t, \mu y^t)}{D^{t+1}_{oc}(x^t, y^t)/D^{t+1}_o(x^t, y^t)} \right] \right\}^{1/2} \\
&\quad \times \left\{ \left[\frac{D^t_{oc}(x^{t+1}, y^{t+1})/D^t_o(x^{t+1}, y^{t+1})}{D^t_{oc}(x^{t+1}, \mu y^t)/D^t_o(x^{t+1}, \mu y^t)} \right] \times \left[\frac{D^{t+1}_{oc}(x^{t+1}, y^{t+1})/D^{t+1}_o(x^{t+1}, y^{t+1})}{D^{t+1}_{oc}(x^{t+1}, \mu y^t)/D^{t+1}_o(x^{t+1}, \mu y^t)} \right] \right\}^{1/2} \\
&\quad \times \left\{ \left[\frac{D^t_{oc}(x^{t+1}, y^t)/D^t_o(x^{t+1}, y^t)}{D^t_{oc}(\lambda x^t, y^t)/D^t_o(\lambda x^t, y^t)} \right] \times \left[\frac{D^{t+1}_{oc}(x^{t+1}, y^t)/D^{t+1}_o(x^{t+1}, y^t)}{D^{t+1}_{oc}(\lambda x^t, y^t)/D^{t+1}_o(\lambda x^t, y^t)} \right] \right\}^{1/2} \\
&= \left[\frac{SE^t(\lambda x^t, \mu y^t)}{SE^t(x^t, y^t)} \times \frac{SE^{t+1}(\lambda x^t, \mu y^t)}{SE^{t+1}(x^t, y^t)} \right]^{1/2} \\
&\quad \times \left[\frac{SE^t(x^{t+1}, y^{t+1})}{SE^t(x^{t+1}, \mu y^t)} \times \frac{SE^{t+1}(x^{t+1}, y^{t+1})}{SE^{t+1}(x^{t+1}, \mu y^t)} \right]^{1/2} \\
&\quad \times \left[\frac{SE^t(x^{t+1}, y^t)}{SE^t(\lambda x^t, y^t)} \times \frac{SE^{t+1}(x^{t+1}, y^t)}{SE^{t+1}(\lambda x^t, y^t)} \right]^{1/2} \\
&= S\Delta(x^t, y^t, \lambda x^t, \mu y^t) \times OM\Delta(\mu y^t, x^{t+1}, y^{t+1}) \times IM\Delta(\lambda x^t, y^t, x^{t+1}).
\end{aligned}
$$

I have used the output distance functions' homogeneity condition multiple times in the derivation, but I might have used it even more to make the formulae for S△ (x^t, y^t, Λ^{xt}, μ^{yt}) and OM△ (Λx^t, x^{t+1}, y^{t+1}) simpler. Equation shows that the radial scale effect S△ (x^t, y^t, Λ^{xt}, μ^{yt}), the output mix effect OM△ (μy^t, x^{t+1}, y^{t+1}), and the input mix effect OM△ (Λx^t, y^t, x^{t+1}) are the components of the activity effect. The geometric mean shape of the activity effect and its three parts, each of which is stated in terms of both period technologies, are used to represent them. If ($y^{t+1}= \Lambda x^t$) or ($x^t=1= \mu y^t$), respectively, neither the output mix effect nor the input mix effect contributes. The Ray and Desli scale change factor is defined in the condition if ($x^t=1= \mu y^t$) and ($y^{t+1}= \Lambda x^t$) as a result of the activity effect collapsing.

$$M_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) = TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times T\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times S\Delta(x^t, y^t, \lambda x^t, \mu y^t) \times OM\Delta(\mu y^t, x^{t+1}, y^{t+1}) \times IM\Delta(\lambda x^t, y^t, x^{t+1}),$$

where ʎ and μ are defined in the footnote and homogeneity permits the substitution of y^t for μy^t. Once more, the decomposition of the Malmquist productivity index does not explicitly account for changes in scale efficiency. The technological change component $TE\triangle_c$ (x^t, y^t, x^{t+1}, y^{t+1}) can also be broken down. The technological change component is decomposed as follows after applying the analyses of Fare and Grosskopf (1996) and Fare et al. (1997a) to the geometric mean formulation based on best practice technologies:

$$\begin{aligned} T\Delta(x^t, y^t, x^{t+1}, y^{t+1}) &= \left[\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right] \times \left[\frac{D_o^t(x^{t+1}, y^{t+1})/D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^{t+1}, y^t)/D_o^{t+1}(x^{t+1}, y^t)}\right]^{1/2} \\ &\quad \times \left[\frac{D_o^{t+1}(x^t, y^t)/D_o^t(x^t, y^t)}{D_o^{t+1}(x^{t+1}, y^t)/D_o^t(x^{t+1}, y^t)}\right]^{1/2} \\ &= T\Delta(x^t, y^t) \times OB(y^t, x^{t+1}, y^{t+1}) \times IB(x^t, y^t, x^{t+1}). \end{aligned}$$

In this decomposition, there are three parts: $T\triangle$ (x^t, y^t, x^{t+1}, y^{t+1}). A ray passing through (x^t; y^t) is used to measure the technological change's magnitude $T\triangle$ (x^t, y^t). The output bias of technical change OB (y^t, x^{t+1}, y^{t+1}) contrasts technical change along a ray through (x^{t+1}〈 y^t) with technical change along a ray through (x^t); it is a measure of technical change along a ray through. Technical change along a ray through (x^t, y^t) is compared to technical change along a ray through (x^{t+1}, y^t) in the input bias of technical change IB (x^t, y^t, x^{t+1}). The Malmquist productivity index can be substituted to produce a seven-way

breakdown. It is quite difficult to separate the output mix change and input mix change components from the output bias and input bias components, thus I do not advocate it. The five-way decomposition is however produced by replacing.

$$M_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) = TE\Delta(x^t, y^t, x^{t+1}, y^{t+1}) \times T\Delta(x^t, y^t) \times OB(y^t, x^{t+1}, y^{t+1}) \times IB(x^t, y^t, x^{t+1}) \times AE(x^t, y^t, x^{t+1}, y^{t+1}).$$

Compared to the decomposition offered by, this decomposition provides an option. It breaks down the Malmquist productivity index into technical efficiency change, three technical change components, and an activity effect, which has been incorporated into the two bias components despite its potential nonradical character.

I get to the conclusion that there are three decompositions of the Malmquist productivity index that are relevant economically. Although one must accept their activity impact as a sufficient reflection of the contribution of scale economies to productivity development, the Ray and Desli decomposition offers the advantage of simplicity. The presented expanded decomposition forgoes simplicity in favour of a more precise assessment of the role of scale economies. A more thorough assessment of the role of technological change is sacrificed by the alternative extended decomposition that was also proposed. Notably, all three decompositions reject the idea of scale efficiency change, which has, in my opinion, confused researchers for years.

3.2 Data collection

In this paper we measured the performance of pharmaceutical industry which are listed in the stock market of Bangladesh. There are 31 companies listed at Dhaka stock exchange. This study considered only those companies which have complete information regarding the variables of the study for 2010-2021. In this study, annual data of 11 companies are taken from Dhaka Stock Exchange annual report and financial statement of selected companies. Annual report of the companies is available in the company's home page.

3.2.1 ACI Pharmaceuticals

ACI is one of Bangladesh's largest pharmaceutical firms, employing more than 5,000 people around the country, and has been partnering life and engendering hope for nearly three decades. ACI Pharma, as a progressive and forward-thinking firm, is committed to improving the health of Bangladeshis by introducing innovative and dependable pharmaceutical goods. ACI pioneered the notion of a quality management system by becoming the first company in Bangladesh to acquire ISO 9001 certification in 1995, and it continues to enhance its operations through a program of continuous improvement. ACI complies with standard environment management policy and was awarded EMS 14001 in 2000, in line with the premise that a pharmaceutical must ensure good environmental management. With the idea that business greatness can only be reached via the pursuit of quality by understanding, accepting, meeting, and exceeding customer expectations, ACI maintains a cordial and supportive connection with Bangladesh's healthcare community. Our goal is to ensuring that world-class, high-quality medicines are available in Bangladesh and around the world. We are proud of our heritage as

the successor to the world-renowned pharmaceutical business ICI.

ACI has been dedicated to producing first-in-class and best-in-class products in important therapeutic areas since its inception in 1992, integrating great R&D with marketing capabilities and continued expansion not only in Bangladesh but also in the worldwide pharmaceutical industry.

Our strength is our capacity to excel in developing generics and technologically sophisticated goods, thanks to a dedicated, knowledgeable, and skilled workforce in manufacturing, product development, process re-engineering, and quality control. ACI now formulates and produces a comprehensive range of over 550 SKUs, which include all main dosage forms of over 250 molecules in nearly 100 therapeutic classes. Biosimilar (biotech) products, insulin, bi-layer tablet, lyophilized products, hormone products, ophthalmic preparations, novel drug delivery system (NDDS), large volume parenteral (LVP), small volume parenteral (SVP), suppositories, effervescent formulation, sustained release dosage formulations, or dispersible products, anaesthetics, metered dose inhaler, dry powder inhaler, nasal spray, and other sophisticated manufacturing technologies have all The company has gained the status of contract manufacturer for renowned international company Servier due to its world-class manufacturing facilities and strict adherence to cGMP and ethics. In Bangladesh, ACI also markets and sells a vaccination product (rabies vaccine) from the world-renowned pharmaceutical company Sanofi. GMP certifications from Kenya, Ivory Coast, and the Philippines have been added to ACI. Pharmaceuticals from our company are exported to 30 nations across four continents. ACI also has 15 nations' Product Marketing Approval. STC (Save the Children) audit confirms ACI's compliance with WHO GMP requirements, saying, "it can be

determined that the ADVANCED CHEMICAL INDUSTRIES Limited and its facilities located in Narayanganj, Bangladesh, operate in accordance with the WHO GMP guidelines." Patients and doctors are the ones who motivate us to keep going. Through cutting-edge chemistry at work, greater innovation, and more practical & convenient solutions, we have produced and captured value for them. Our goal is to ensure that all sick people around the world have access to high-quality, affordable medicines. We are extremely concerned about patients' and their families' unmet medical needs, which are always changing.

3.2.2 AMBEE PHARMACEUTICALS LTD

A fast-growing corporation, was founded in Bangladesh in 1976. This public limited company was established in Bangladesh on February 4th, 1976, under the Companies Act, 1913. Ambee has a joint venture with Hungary's Medimpex, a well-known global corporation. Ambee began with a modest 17 joint ventured items and is currently up and running with 76. Tablets, capsules, liquids, gel in tubes, and injectables are all available. Its operations region spans the entire country, with a huge number of field workers working hard to establish demand for the company's products in every corner. Apart from its National Distribution Cell in Dhaka, the corporation operates four outside Depots in Khulna, Bogra, Chittagong, and Sylhet. Ambee Pharmaceutical Ltd. (APL) had just 30 field forces and had only introduced 17 products when it was founded in February 1976. In its first year, the company made a bit more than 1 crore in revenue. Since then, the company has focused on marketing the most urgently required novel formulations, and as of 2001, APL has 68 medications in capsule, liquid, gel, and injectable form. The company now has its own distribution network that spans the entire

country. The Distribution Department of Ambee includes five depots and employs around 150 individuals. With 200 individuals on the road, the Sales Team has grown to a sizeable size. Ambee has been successful in exploring the export market in addition to the local market. In 2000, the company achieved one export contract with Myanmar, and is currently pursuing similar commercial opportunities with African and SAARC countries. Our goal is to achieve company excellence by exceeding client expectations via quality. To achieve consistent product quality, we use a Quality Management System. We also follow Good Manufacturing Practices (GMP) as suggested by the World Health Organization (WHO) for pharmaceutical operations and meet all National Regulatory Requirements in our company affairs. The management of Ambee Pharmaceuticals Limited is dedicated to its commitment to quality and all workers of the firm follow specified procedures to ensure quality standards. Our strength comes from the fact that we have a dedicated and high-quality team of specialists working for us. The company's Human Resources are a valuable asset, and they are regularly trained in order to improve work procedures. Ambee Pharmaceuticals Ltd. received ISO 9001 certification in 2001. The ISO 9001 certificate is an international acknowledgement of this organization's quality management system, which meets the ISO 9001 standard. United Registrar of Systems Ltd. (URS) of the United Kingdom gave this certificate. Only a few of Bangladesh's 250 pharmaceutical companies have achieved ISO 9001 certification, and Ambee is one of them.

3.2.3 ACME Laboratories Ltd

In Bangladesh, ACME Laboratories Ltd. Is a renowned manufacturer of world-class and high-quality pharmaceutical products. We presently

manufacture approximately 500 medications in various dosage forms for a variety of therapeutic categories, including anti-infectives, cardiovascular, antidiabetics, gastrointestinal, CNS, respiratory disease, and many more. Because of our success in the local market, we decided to expand into the international market. Over the years, we have established a strong presence in Southeast Asia, Africa, and Central America, and we are constantly exploring new horizons to improve the quality of life for patients, to help our customers succeed, and to help meet global challenges. We are constantly expanding our facilities, capabilities, and portfolio to meet the growing health care needs, thanks to the great knowledge, professionalism, and devotion of more than 7000 workers. Our purpose to secure everyone's health, vitality, and happiness unites, inspires, and fuels us. We have been committed to providing solutions to our most pressing health care requirements from our founding in 1954 by Mr. Hamidur Rahman Sinha, an entrepreneur and philanthropist in this region of the then British divided Indian subcontinent. More than half a century later, we continue committed to our founder's vision and principles of producing high-quality medications with integrity, proactivity, team spirit, excellence, and a passion to win, as well as meeting social and environmental demands. The pharmaceutical industry has had incredible expansion and success during the last few decades. Our company draws on a strong tradition of high-quality formulations and a solid pipeline of promising generic medicines at an accessible price to satisfy the health care demands, with more than 60 years of competence in medicine and science. ACME has stood for excellence, business success, and ethical entrepreneurship since 1954. Our objective to ensure mankind's health, vigor, and happiness is built on our heritage and ideals. We are a corporation that is ISO 9001:2015 certified. “Perpetual Quest for Excellence” is our quality slogan.

3.2.4 Beacon Pharmaceuticals Limited

Beacon Pharmaceuticals Limited is Bangladesh's largest oncology company and one of the country's fastest-growing pharmaceutical firms. In 2006, the company began operations. Beacon is now one of Bangladesh's leading cancer pharmaceutical businesses. Beacon's manufacturing plant features the best infrastructure and facilities, which were created and engineered by European consultants to meet world-class standards such as US FDA, UK MHRA, TGA Australia, and WHO GMP. Beacon has dedicated manufacturing facilities for life-saving cancer, biotech, hi-tech, and traditional general items. The company manufactures more than 200 world class generic pharmaceuticals and also successfully debuted a number global first generic drug. Beacon exports its medicines to numerous nations in Asia, Africa, Europe, and Latin America after fulfilling local need.

3.2.5 Beximco Pharmaceuticals Ltd

Beximco Pharmaceuticals Ltd (Beximco Pharma) is a new generic pharma company dedicated to making medicines cheaper. The company's cutting-edge production facilities have been approved by regulatory authorities in the United States, Australia, the European Union, Canada, and Brazil, among others, and it is now focusing on expanding its footprint in a variety of emerging and developed markets across the world. Beximco Pharma is constantly expanding its product line, with over 500 goods covering a wide range of therapeutic areas. The company has distinguished itself by supplying a variety of high-tech, specialized products that are difficult to duplicate. To make BPL genuinely multinational, our product development team maintains a strong research

commitment in formulation development. As a generic medication company, we have placed a high premium on developing and expanding capabilities to excel at creating technologically sophisticated goods in order to differentiate ourselves. their R&D team creates a wide range of generic pharmaceuticals, including formulations that are difficult to duplicate in specific speciality areas. Multi-layer tablets, prolonged release formulations, dispersible tablets, CFC-free inhalers, prefilled syringes, lyophilized injectables, sterile ophthalmics, and other products have all been created successfully. they have made a number of submissions to regulatory agencies in the EU and the United States, and there is a growing pipeline of filings for regulated markets. their research and development activities are driven by technology advancement and closely focused on market needs. A new, cutting-edge research centre is being built to help with the creation of novel and complex products with the goal of creating new market prospects. The main manufacturing site is a 23-acre facility near Dhaka that houses facilities for producing tablets, capsules, intravenous fluids, liquids, creams, ointments, suppositories, metered dose inhalers, ophthalmic drops, large volume parenterals, sterile ophthalmics, prefilled syringes, and lyophilized injectables, among other things. The location includes its own utility infrastructure, including water purification and liquid nitrogen generation facilities, to provide adequate generation and distribution of power with a 15 MW installed capacity. Our penicillin operations (both API and formulation) are located 21 kilometres apart from the main location in Kaliakoir. BPL's dynamic staff of over 4,700 employees is the driving force behind its growth. Their dedicated and highly capable employees are our most important resource in achieving our purpose, and they continually place people at the centre of their approach. We acknowledge that it is our people's unwavering efforts that have propelled us to greater heights over time. Over 1,500

specialists, including pharmacists, chemists, doctors, engineers, microbiologists, researchers, and business grads, are currently part of their strong pool of expertise.

To promote empowerment and inspire creativity, we at Beximco Pharma strive to build, promote, and preserve an inclusive, high-performing, and diverse culture for our workers. They place a premium on building capacity, honing abilities, and facilitating their collective and individual success.

3.2.6 IBN SINA Pharmaceutical Industry Ltd.

In Bangladesh, the IBN SINA Pharmaceutical Industry Ltd. is a significant pharmaceutical firm. The firm was established in 1983. The production facilities are located in Gazipur, 56 kilometres from Dhaka's central business district, on a 15-acre complex. The manufacturing plant was built using cutting-edge technology and is outfitted with high-grade machinery for the production and quality control of a wide range of dosage forms for a variety of therapeutic classes. In addition to modern treatments, the company promotes traditional herbal/unani medicines. As a result, its manufacturing plant is divided into two main units: pharmaceutical manufacturing and natural medicine manufacturing (herbal/unani). Both units are committed to cGMP compliance and the highest ethical standards.

IP's objective as a good corporate citizen is to serve humanity in an ethical, socially and environmentally responsible, and, of course, sustainable manner.

Ibn Sina Pharmaceutical Industry Ltd. is committed to making sustainability an integral part of enabling people in good health to live better lives, improving environmental and social performance through mainstream operation of health services while ensuring the availability of quality medicines, which we refer to as our corporate footprint.

3.2.7 NIPRO JMI Pharma Ltd (NJP)

NIPRO JMI Pharma Ltd Is a dependable and well-known pharmaceutical firm in Bangladesh. The novel journey began in 2012 with the involvement of NIPRO Corporation, a large Japanese multinational corporation. We produce and market pharmaceuticals in accordance with WHO-recommended cGMP norms (World Health Organization).

NJP is committed to providing world-class products to the ailing humanity of the country and abroad through HCP (Healthcare Professionals). We put a strong emphasis on incorporating new ideas into our work. We intend to establish our company as a national and international healthcare brand.

3.2.8 Orion Pharma Ltd.

Orion Pharma Ltd. Is one of Bangladesh's leading pharmaceutical firms, contributing to the country's human health care by delivering high-quality branded-generic drugs. We at Orion Pharma Ltd. believe that 'Quality never ends,' and we refuse to accept anything until it meets or exceeds

the current level. For this reason, Orion Pharma Ltd. has consistently outperformed the market growth over the last few years. In January 2003, the company was received the ISO-9001: 2000 Certificate for providing high-quality products to its devoted clients. Orion Pharma Ltd. now has four decades of significant experience infused with technological and professional expertise.

Orion Pharma Ltd. is one of the ORION Group's 27 sister companies. With over 120 brands, 225 dosage forms, and 37 different therapeutic categories, Orion Pharma Ltd. is making a substantial contribution to Bangladesh's healthcare solution, including lifesaving anticancer drugs, lyophilized injectables, and other chronic care and primary care medicines. Physicians prescribe us with trust and confidence.

Globalization!! Orion Pharma Ltd. is now concerned about this word. With the quick speed of innovation in pharmaceutical technology, regulatory requirements, and treatment alternatives, the landscape of the global pharmaceutical market is always evolving. Orion Pharma Ltd. has already begun building of a new facility, which will be one of the latest and finest facilities for pharmaceutical finished products in Southeast Asia, keeping in mind the advancement of technological excellence in Pharma and Healthcare. The facilities will be built in accordance with current 'Good Manufacturing Practices' standards set by international regulatory agencies such as the US Food and Drug Administration, the UK Medicines and Healthcare Products Regulatory Agency, and the Australian Therapeutic Goods Administration, among others.

This new facility will be the largest in Bangladesh's pharmaceutical sector in terms of investment, covered area, number of dosage form variants to be produced, and pharmaceutical technology, waste management,

monitoring system, and environmental friendliness.

Orion Pharma Ltd. takes a bold step forward in international business. Orion has an overseas marketing network in Afghanistan, Armenia, Bhutan, Cambodia, Jamaica, Lesotho, Myanmar, Nepal, Philippines, and Sri Lanka, with the goal of offering healthcare services globally. Orion is also pursuing regulatory licenses and seeking business prospects in a number of nations, including Sudan, Kenya, Barbados, and others across the globe.

Our long-held ambition is to become one of the leading contributors to the worldwide pharmaceutical market, with a focus on innovation, research, and quality management, and thereby to set a new global standard.

Our goal is to become a world-class pharmaceutical company specializing in generic finished products. 'Quality never ends,' is our philosophy. As a result, Orion Pharma Ltd. has seen significant growth in recent years. In January 2003, Orion Pharma Ltd. was issued the ISO-9001: 2000 Certificate, which is WHO recognized GMP certified.

3.2.9 Renata Limited

Renata Limited (previously Pfizer Limited) is one of Bangladesh's most prominent and rapidly expanding pharmaceutical and animal health product enterprises. Pfizer (Bangladesh) Limited, a subsidiary of Pfizer, began operations in 1972. Pfizer handed over control of its Bangladesh operations to local shareholders in 1993, and the company was renamed Renata Limited.

Renata Limited's main activities are human pharmaceuticals and animal health products. It is the fourth largest pharmaceutical firm in Bangladesh, as well as the market leader in animal health goods. Renata items are also sold in Afghanistan, Belize, Cambodia, Ethiopia, Guyana, Honduras, Hong Kong, Kenya, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, and Vietnam. The company has a market valuation of over $1 billion and is listed on the Dhaka Stock Exchange.

The company operates eleven production plants across three locations. Products are distributed through 19 depots around the country. Renata has a workforce of about 8,000 workers.

3.2.10 SQUARE

Today, SQUARE stands for a name — a state of mind. However, the road to growth and prosperity has not been easy. It has grown from its humble beginnings in 1958 to become one of Bangladesh's leading companies. Since 1985, the flagship firm, Square Pharmaceuticals Ltd., has had a strong leadership position in Bangladesh's pharmaceutical industry and is currently on its path to becoming a high-performance worldwide player. Since 1985, SQUARE Pharmaceuticals Limited has been the largest pharmaceutical firm in Bangladesh, ranking first among all national and multinational companies. It was founded in 1958, became a public limited company in 1991, and began trading on stock exchanges in 1995. Square Pharma had a turnover of BDT 50.87 billion (US$ 609.18 million) in July 2018, with a market share of 16.95 percent and a growth rate of 10.85 percent (July 2018-June 2019). SQUARE Pharmaceuticals Limited has broadened its service offerings to include the

global market. It was the first company to export medications from Bangladesh in 1987, and it continues to do so today, exporting antibiotics and other pharmaceutical items. Currently, 42 nations are represented in the export market. Square Pharmaceuticals Limited's trustworthiness has been demonstrated by this expansion in business and services.

3.3 Company Type

Bangladesh has 2 kind of company one is who produce Formulation and Bulk Drug both and another who produce only Bulk Drug. Out of 11 companies that I use for my studies four of them produce bulk drug and rest of seven produce both.

The chemical molecule in a pharmaceutical product (the medicines we buy from the chemist) that gives the product the purported therapeutic action is known as a bulk drug, also known as an active pharmaceutical ingredient (API).

In other words, the ingredient penicillin, for instance is what makes the product a pharmaceutical. This shows that items marketed as medicines contain components besides the API. The bulk substance would invariably remain the same because it is the identity of the treatment, however these inactive ingredients-excipients might or might not change from product to product. A product ceases to be a medicine when the active ingredient is removed, and a new medicine is created when it is altered. One can wonder what the patient understands by the presence of the inactive components. Changes to inactive components have an effect on the curative quality of the majority of the current bulk medications. This implies that, subject to financial considerations and chemical viability,

drug producers are essentially free to construct bulk medications using any excipients they like. Therefore, the medications available in the form of tablets, capsules, syrups, drops, intravenous fluids, etc. Simply said, the items we refer to as medications are formulations (of bulk drugs) rather than bulk drugs in and of themselves.

What legal steps must be taken before a new bulk medicine or formulation may be sold?

Launching a new bulk medicine is a very costly endeavour that calls for extensive scientific study, significant financial risk, and validation tests. According to some MNCs, a new medication innovation costs $800 million. When a firm intends to launch a new chemical entity bulk drug with a suspected therapeutic effect, an investigational new drug application is submitted to a regulator. The formulator, on the other hand, only needs to demonstrate that his product is bio-equivalent to the currently available formulations in the class, meaning that the rate and extent of drug absorption differ outside of acceptable bounds from the existing formulation(s) of the bulk drug. The formulators are essentially immune from this need in the case of established pharmaceuticals, whereas for drugs that have up to this point been covered by a patent, only the bulk of the formulation must be disclosed. The formulators are essentially exempt from this requirement for established drugs, but they must complete bioequivalence studies for marketing authorization for at least the first few new formulators for drugs that have up to this point been covered by a patent, which means that only the formulation(s) of the bulk drug have been available. This is what happens when Indian companies launch their formulations of the patent-expired medication immediately following the expiration of the patent.

Can there be more than one bulk medication in a formulation?

There are several formulations that contain more than one bulk medicine, even though the majority of formulations only contain one bulk drug. Such fixed dose combination (FDC) formulations are becoming more prevalent. A novel FDC created by mixing two bulk medications is referred to by regulators as a "new medicine" since, unlike inactive chemicals, these active ingredients must have their safety and efficacy confirmed because to the possibility of clinically harmful interactions. A generic medication is what?

A generic medication is one that bears the API's widely recognized scientific name as its name. For instance, if a business sells the antibiotic Ciprofloxacin under that name, it is generic Ciprofloxacin; likewise, if a drug formulation is marketed as Ciprofloxacin in the retail sector, it is a generic version of the drug. A medicine is considered to be branded if a business distributes the same formulation under its own distinctive brand name. Generic names are not capitalized, although brand names are. Prices for generic goods should typically be less expensive than those for branded goods. Prescriptions for brand-name drugs are also becoming common, even though prescribing a drug's generic name may be a model of ethical behaviour for a licensed medical professional. The phrase "generic drug," however, is also figurative and contextual. This is due to the fact that it is increasingly being used to refer to non-patent medications. Branded off-patent medications are also referred to as generic medications in highly regulated and patent-heavy markets like the US, whereas a non-branded medication is a generic medication in nations like India where there is no product patent on pharmaceuticals. Non-branded medications are also referred to as " generics" to distinguish between the two definitions of generics.

Chapter 4 Determinants of TFPCHG

The variables used as possible determinants of TFPCHG are salary, asset, row material, salary and electricity & gas

te= Efficiency change, thchch= Technology change, pech=Pure efficiency change, sech=Scale efficiency change, tfpchch= Total factor productivity change.

Tables 1 and 2 show the efficiency scores of the 11 pharmaceutical companies studied between 2010 and 2021. The productivity of a decision-making unit is evaluated based on the value of one, according to the Malmquist index study presented by (Fare et al., 1994). The positive TFPCH is explained by a value greater than unity. comparison of the growth of that decision making unit (DMU) over time (t+1).

Table 1. Malmquist Index summary of annual means

MALMQUIST INDEX SUMMARY OF ANNUAL MEANS						
year	effch	thchch	pech	sech	tfpch	
2011	0.906	1.19	1.116	0.811	1.077	
2012	1.009	1.143	0.944	1.069	1.153	
2013	1.183	1.022	0.972	1.217	1.209	
2014	1.236	0.781	0.999	1.237	0.965	
2015	0.769	1.422	0.882	0.872	1.094	
2016	1.046	0.966	0.948	1.104	1.01	
2017	1.061	1.123	1.114	0.953	1.191	
2018	0.766	1.258	0.786	0.974	0.963	
2019	1.224	0.928	1.214	1.008	1.136	
2020	0.79	1.082	1.022	0.773	0.855	
2021	1.229	0.844	1.081	1.137	1.037	

Technical Efficiency Change, Technological Change, Pure Technical Efficiency Change, Scale Technical Efficiency Change, and Total Factor Productivity (TFPCH) Change for all 10 enterprises are summarized in Table 1. Except for the year 2015 amd 2018, all of the companies exhibit efficiency in the range of 4.4 percent to 23.6 percent in terms of Technical Efficiency Change throughout the study period. In the case of technological change, all enterprises in the same year had a negative efficiency of 23 percent, 15.6 percent,7.2 percent, 3.4 percent rest of the year it shows upto 42 percent growth . This shortfall is a big setback as compared to previous years. Despite the fact that enterprises recovered capacity the following year and had a 11.5 percent increase in TFPCH than last year. In terms of pure technical efficiency, corporations saw very ups and down trand between year 2011 to 2021. In year 2018 shows hight negetive efficiency that was 21.16 percent where in the year 2019 was the highgt positive growth 21.4 percent .The table shows that negative efficiency ranges from 0.1 percent to 21.4 percent in the remaining years. In the case of Scale Efficiency Change of the companies across the study period, year 2020 was hight negetive year that was 22.7 percent and hight growth was in year 2014 that was 23.7 percent. When it comes to the means, scale inefficiency, rather than pure technical inefficiency, is the main source of technical inefficiency in the pharmaceutical sector. Except for the year 2014, 2018,2020, the Total Factor Productivity (TFPCH) growth of the companies was found to be positive, with a range of 0.037 percent to 20.9 percent.

Figure 1 showing the line graph of technical efficiency, technological change and total factor productivity (TFPCH). (TFPCH), TE and THCHCH, the two most noteworthy criteria, have followed an inverse pattern throughout the study period. We can see from the line graph the main factor TFPCH shows feactuation from the starting to the end of

study priod. Where TE represent continues upwath trande from year 2011 to 2014 after that itb shows spike fall and start ups and down trand.

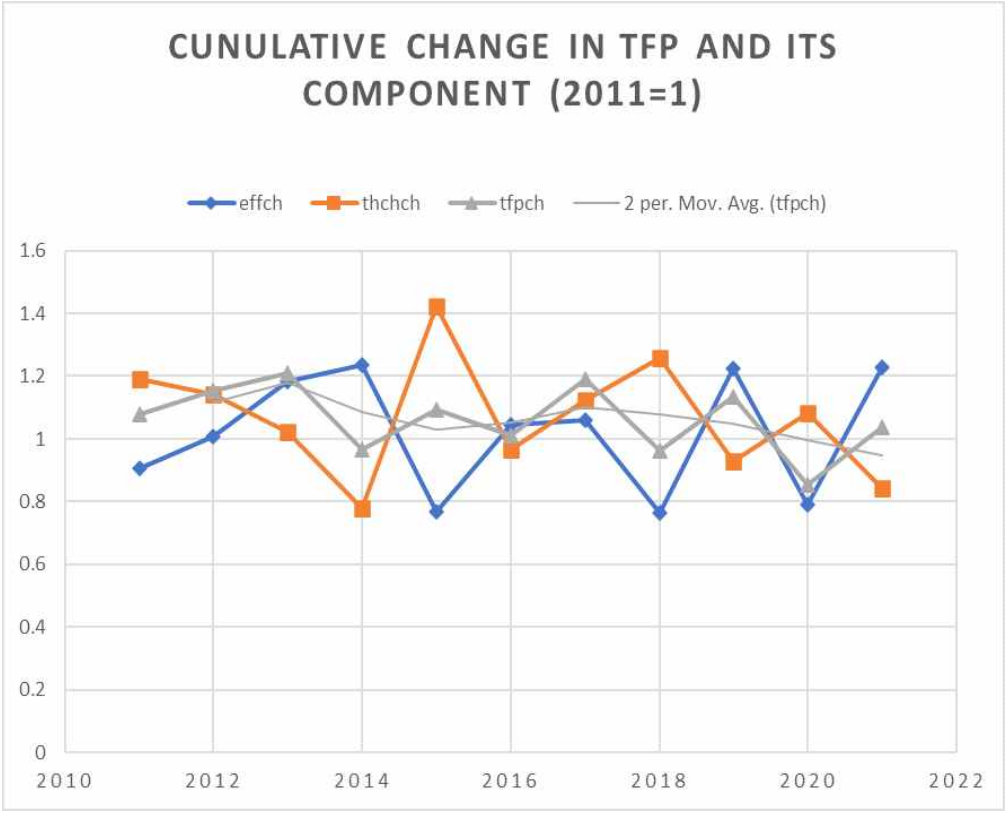

Figure 2. How two main factor total factor productivity.

The line graph of technical efficiency, technological change, and total factor productivity is shown in Figure 1. (TFPCH). TE and THCHCH, the two most noteworthy criteria, have followed an inverse pattern throughout the study period. It should also be noted that the most significant interruption occurred in 2015 for both patterns. TFPCH showed a flactuation from 2009 to 2012, owing to a constant decrease in THCHCH excetp year 2015. Table 1 shows that THCHCH has a

considerable influence on TFPCH. Similar studies on MI and TFPCH (Ahn & Min, 2014; Arjomandi, Valadkhani, & O'Brien, 2014) demonstrate the link between THCHCH and macroeconomic factors such as government policy or limits, country-specific challenges, financial stability, and industry-wide technological improvement. The degree of adoption capability of the sector with macroeconomic external business environment and changes, as shown in table 1, explains a chance for further improvement in TFPCH. Furthermore, at the middle of 2012, Bangladesh experienced some economic recession (Aziz, Janor, & Mahadi, 2013). Of course, what factors may influence technical advancements and by how much is a topic of debate.

Table 2. Malmquist Index summary of firm mean

MALMQUIST INDEX SUMMARY OF FIRM MEANS					
firm	effch	thchch	pech	sech	tfpch
ACI	1	1.069	1	1	1.069
Ambee	1.067	1	0.89	0.95	0.95
Acme	0.957	1.107	0.973	0.983	1.059
Beacon	1.043	1.018	0.971	1.074	1.062
Bexemco	1.091	1.345	1.078	1.013	1.468
Ibnesinha	0.963	1.002	0.977	0.986	0.965
JMI	1.059	0.979	1	1.059	1.037
Merico	1	1.072	1	1	1.072
Orion	1.042	1.087	1	1.042	1.133
Renata	1.024	0.946	1.013	1.01	0.968
Square	0.982	0.955	0.995	0.986	0.938

technological efficiency, with annual increases ranging from 0.02 percent to 34.5 percent. Over the course of the analysis, 3 (three) companies, namely JMI, Renata and Square were found to be inefficient. In terms of technological progress, all of the enterprises have had annual growth of 5.8% on average. Inefficiency of roughly 3% per year has been documented in both pure technological efficiency and scale efficiency. According to the data, a total of 7 enterprises have experienced positive Total Factor Productivity (TFPCH) growth changes. Beximco and Orion were discovered to be at the top of the list. The remaining four corporations all had negative TFPCH changes, ranging from −6.2 percent to 5.0 percent annually. For Square and Beximco, the lowest and largest TFPCH changes were reported, respectively.

Figure 3 Total factor productivity graph of all firm.

From this figure we can clearly see that Beximco is the best performing company. Its mean that Beximco doing best with there all set of

efficiency they are paying right amount of salary, using right amount electricity, asset, row material and they are doing best sale with this too. From this graph we can see square is the least performing company. From Tabil 2 we can see that they have problem in all kind off efficiency.

Table 3. Malmquist Index summary of firm means (formulation and bulk drug company)

MALMQUIST INDEX SUMMARY OF FIRM MEANS (FORMULATIOI					
firm	effch	thchch	pech	sech	tfpch
Ambee	1.067	1	0.89	0.95	0.95
Beacon	1.043	1.018	0.971	1.074	1.062
Ibnesinha	0.963	1.002	0.977	0.986	0.965
JMI	1.059	0.979	1	1.059	1.037
Merico	1	1.072	1	1	1.072
Orion	1.042	1.087	1	1.042	1.133
Renata	1.024	0.946	1.013	1.01	0.968

more inefficient they should take step for that ibnesinha also facing same problem. On the other hand Renata facing main problem in technology efficiency. Figure $ also mention that. Here we can say almost 50 percent of the company inefficient.

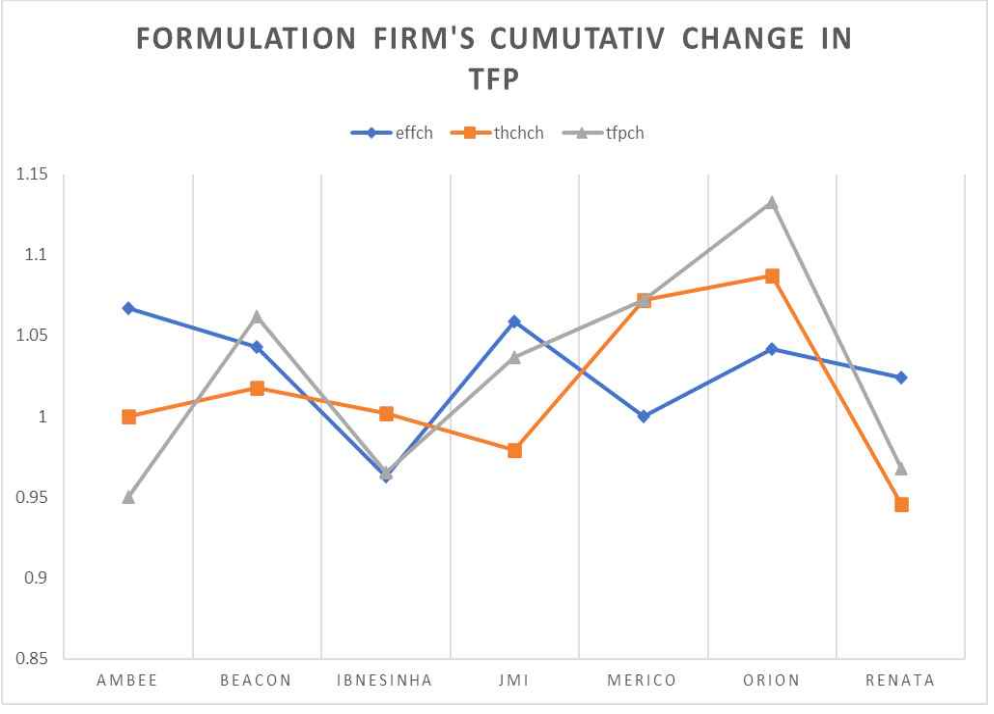

Figure 4. How two main factor effect total factor productivity

Table 4.Malmquist Index summary of firm means (Bulk drug company)

MALMQUIST INDEX SUMMARY OF FIRM MEANS (BULK DRAG)					
firm	effch	thchch	pech	sech	tfpch
ACI	1	1.069	1	1	1.069
Acme	0.957	1.107	0.973	0.983	1.059
Bexemco	1.091	1.345	1.078	1.013	1.468
Square	0.982	0.955	0.995	0.986	0.938

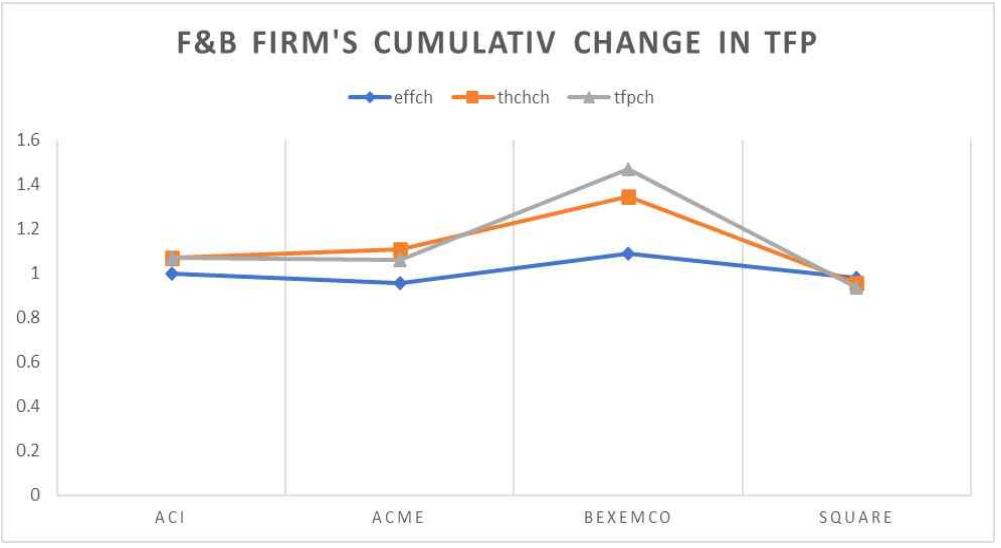

Figure 5. How two main factor effect total factor productivity.

Chapter 5 Conclusion

By bridging the information gap between the growth of the existing industry and its actual productivity, this study has added to the body of literature. Over the study period from 2011 to 2021, the results showed that the Bangladeshi pharmaceutical industry's productivity increased on average. The model's findings demonstrate that the industry's marginal productivity improvement is solely the result of new technological innovations that have been adopted and developed by individual enterprises. The general level of technical effectiveness has declined. The expanding efficiency gap among pharmaceutical companies, with less efficient companies moving further away from the frontier, is likely to blame for the reduction in efficiency. The increased performance dispersion's causes are unclear, but it could mean a number of things. It is clear that the bulk of Bangladesh's large pharmaceutical businesses specialize in process patenting rather than product patenting. A better profile in production and sales can readily be produced by such industry conditions. It might not be able to achieve sustainability over the long term via automation and patent purchases. Both large and medium-sized businesses have been shown to have pushed toward automating their current manufacturing facilities in order to improve production over the past two decades. Despite the fact that output and sales increased, the cost of production remained relatively constant. Major studies reveal that "Product Patent"—rather than "Process Patent"—is what determines a pharmaceutical company's viability and productivity. This burgeoning industrial sector may experience an utter shock in the near future if self-reliance on the production and innovation of raw materials is not established. From this study we can say that Bulk drug manufacturing companies' efficiency is better than the companies who manufacture both

formulation and bulk drug. Seven industry who produce both should follow their management and salary system and technology sector too.

Reference

[1] Ahn, Y.-H., & Min, H. (2014). Evaluating the multi-period operating efficiency of international airports using data envelopment analysis and the Malmquist productivity index. Journal of Air Transport Management, 39(0), 12-22. doi: http://dx.doi.org/10.1016/j.jairtraman.2014.03.005

[2] Anesary, M. A. W., Hossain, M. J., Mamun, M. R. A., Salam, M., Rahman, K. S., Morshed, M. M.,... Kabir, Z. M. (2014). Pharmaceutical sector of Bangladesh: prospects and challenges.

[3] Arjomandi, A., Valadkhani, A., & O'Brien, M. (2014). Analysing banks' intermediation and operational performance using the Hicks-Moorsteen TFP index: The case of Iran. Research in International Business and Finance, 30(0), 111-125. doi: http://dx.doi.org/10.1016/j.ribaf.2013.06.003

[4] Azam, M. M., & Richardson, K. (2010). Pharmaceutical Patent Protection and TRIPS Challenges for Bangladesh: An Apprisal of Bangladesh's Patent Office and Department of Drug Administration. Bond Law Review, 22(2), 212-219.

[5] Aziz, N. A. A., Janor, R. M., & Mahadi, R. (2013). Comparative Departmental Efficiency Analysis within a University: A DEA Approach. Procedia Social and Behavioral Sciences, 90(0), 540-548. doi: - http://dx.doi.org/10.1016/j.sbspro.2013.07.124

[6] Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management science, 30(9), 1078-1092.

[7] Caves, D., Christensen, L., & Diewert, W. (1982). The economic theory of index numbers and the measurement of input, output, and productivity. Econometrica, 6, 1393-1414.

[8] Centre, I. T. (2007). Supply and demand survey on pharmaceuticals and natural products- Bangladesh (December, 2007 ed.). Dhaka: International Trade Center-SouthSouth trade promotion program.

[9] Chou, Y.-C., Shao, B. B. M., & Lin, W. T. (2012). Performance evaluation of production of IT capital goods across OECD countries: A stochastic frontier approach to Malmquist index. Decision Support Systems, 54(1), 173-184. doi: http://dx.doi.org/10.1016/j.dss.2012.05.003

[10] Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). An introduction to efficiency and productivity analysis. USA: Springer.

[11] Cooper, W. W., Seiford, L. M., & Tone, K. (2007). Efficiency change overtime Data envelopment analysis- A Comprehensive Text with Models, Applications, References and DEA-Solver Software Second Edition (pp. 351-375). USA: Springer.

[12] Davamanirajan, P., Kauffman, R. J., Kriebel, C. H., & Mukhopadhyay, T. (2006). Systems Design, Process Performance and Economic Outcomes. Paper presented at the 39th Annual Hawaii International Conference on System Sciences.

[13] Debreu, G. (1951). The coefficient of resource utilization. Econometrica: Journal of the Econometric Society, 19(3), 273-292. [14] Din, M.-u., Ghani, E., & Mahmood, T. (2007). Technical Efficiency of Pakistan's Manufacturing Sector: A Stochastic Frontier and Data Envelopment Analysis. The Pakistan Development Review, 46(1), 1-18.

[15] Fare, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity growth, technical progress and Efficiency changes in Industrial Countries. American Economic Review, 84, 66-83. [16] Hashimoto, A., & Haneda, S. (2008). Measuring the change in R&D efficiency of the Japanese pharmaceutical industry. Research Policy, 37(10), 1892-2836.

[17] Hossain, N. U. I., Nur, F., & Habib, M. A. (2014). Achieving competitive advantage through practicing TQM tools in pharmaceuticals company. Journal of Mechanical Engineering, 43(2), 103-109.

[18] Jajri, I., & Ismail, R. (2007). Technical Efficiency, Technological Change and Total Factor Productivity Growth in Malaysian Manufacturing Sector. ICFAI Journal of Industrial Economics, 4(4), 1-18. [19] Kartz, J. M. (1969). Production Functions, Foreign Investment and Growth, A Study Based on the Manufacturing Sector 1946-1961. Amsterdam: North Holland Publishing Company.

[20] Kirigia, J. M., Emrouznejad, A., Sambo, L. G., Munguti, N., & Liambila, W. (2004). Using data envelopment analysis to measure the technical efficiency of public health centers in Kenya. Journal of Medical Systems, 28(02), 155-166.

[21] Koopmans, T. C. (1957). Three essays on the state of economic science (Vol. 21). New York: McGraw-Hill.

[22] Mahadevan, R. (2002). A DEA approach to understanding the productivity growth of Malaysia's manufacturing industries. Asia Pacific Journal of Management, 19(4), 587-600. [23] Malmquist, S. (1953). Index Numbers and Indifference Surfaces. Trabajos Estatistica, 4, 209-242.

[24] Mazumdar, M., & Rajeev, M. (2009). Comparing the Efficiency and Productivity of the Indian Pharmaceutical Firms: A Malmquist-Meta-Frontier Approach Working Paper 223 (Vol. 8, pp. 1-41). Bangalore: The Institute for Social and Economic Change.

[25] Mohamad, N. H., & Said, F. (2011). Efficiency and innovation in selected Malaysian government-linked companies for the period 2003 to 2008. African Journal of Business Management, 5(25), 10259-10270.

[26] Mohamad, N. H., & Said, F. (2012). Decomposing total factor productivity growth in small and medium enterprises, SMEs. Indian Journal of Science & Technology, 5(5), 2706-2712.

[27] Ramli, N. A., & Munisamy, S. (2013). Technical Efficiency and Eco-Efficiency in Manufacturing Industry: A Non-Parametric Frontier Approach. International Review of Business Research, 9(5), 1-11.

[28] Royhan, P. (2013). Market access challenges and opportunities for Bangladesh pharmaceutical products under TRIPS. Journal of Intellectual Property Law & Practice, 8(12), 932-938.

[29] Saranga, H., & Phani, B. V. (2004). The Indian Pharmaceutical Industry-An Overview on Cost Efficiency using DEA Working paper. India: Indian Institute of Technology Kanpur.

[30] Schiersch, A. (2012). Firm size and efficiency in the German mechanical engineering industry. Small Business Economics, 40(2), 335-350.

[31] Tripathy, I. G., Yadav, S. S., & Sharma, S. (2013). Efficiency and productivity in the process and product patent regimes: empirical evidence from the Indian pharmaceutical industry. International Journal of Economics and Business Research, 6(1), 1-19.

국 문 초 록

- 방글라데시 제약 산업의 총 요소 생산성 및 효율성 -

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사 미 물

방글라데시의 제약 산업은 연간 두 자릿수 성장률로 현재 전체 국내 수요의 약 97%를 충족할 수 있습니다. 그러나 기업이 얼마나 잘 생산하는지에 대한 질문이 제기됩니다. 이 연구는 DEA(Data Envelopment Analysis)를 사용하여 2011년부터 2021년까지 방글라데시 제약 부문의 기술 효율성을 측정합니다. 연간 매출 1개, 입력 4개 1. 고정 자산 비용, 2. 원자재 비용, 3. 전기 및 가스 및 4 급여 비용. 우리는 비모수적 DEA를 사용합니다. 분석 결과, 연간 5.2%의 값을 갖는 Malmquist 총요소생산성지수(TFPCH)가 연구 기간 동안 약간 증가하는 추세를 유지하고 있음을 보여줍니다. 또한 연간 10.8%의 긍정적인 증가로 기술 발전이 TFPCH 성장의 주요 동인으로 밝혀졌습니다. 또한 각각 5.1%, 3.1% 및 345%의 값으로 기술 효율성, 순수 효율성 및 규모 효율성의 모든 변경 사항이 퇴보했습니다.

기술 발전과 전반적인 효율성 저하로 인해 생산성이 전반적으로 증가했습니다. 따라서 효율성 증가가 아니라 생산성 증가는 전적으로 기술 혁신의 결과입니다. 순수한 기술적 비효율 대신 규모의 비효율은 제약 부문의 비효율의 주요 원인입니다. 가지 유형의 회사 벌크 의약품 제조업체와 벌크 의약품 및 제제 의약품 제조업체가 있습니다. 그 중 벌크 의약품 제조업체는 다른 제조업체보다 더 나은 효율성을 보여줍니다.

【키워드】: 데이터 포락선 분석. 효율성, Malmquist, 생산성, 대량 의약품, 제제 의약품