EFFICIENCY MEASUREMENT OF PHARMACEUTICAL INDUSTRY USING THE MALMQUIST TOTAL PRODUCTIVITY INDEX

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ABSTRACT

The pharmaceutical industry of Bangladesh is now meeting around 97% of total domestic demand with an annual two digit growth rate. But the question arises as to whether the firms produce efficiently? The paper measures technical efficiency of the pharmaceutical industry of Bangladesh using Data Envelopment Analysis (DEA) over a period of 2009 to 2013. We use the non-parametric DEA with one output- annual sales and three inputs; viz. (i) fixed asset; (ii) raw material cost; and (iii) cost of salary. Results of the analysis reveal that Malmquist total factor productivity index (TPI) has maintained a slightly upward trend during the study period with a value of 4.7% annually. It has also been observed that the major contributor of TPI growth is technological change with a value of 10.8% positive growth annually. Additionally, all changes of technical efficiency; pure efficiency and scale efficiency have regressed with values of 5.5%, 2.1% and 3.5% respectively. The overall productivity progress was due to technological progress and an overall efficiency regress. Thus, the gains in productivity are entirely due to technological advancements, and not efficiency improvement. The main source of inefficiency in pharmaceutical industry is scale inefficiency rather than pure technical inefficiency.

Keywords*: Efficiency; Data Envelopment Analysis; Malmquist Productivity Index; Pharmaceutical.*

INTRODUCTION

Since independence in 1971, Bangladesh has faced multidimensional challenges in the way to economic development and sustainability. Ensuring productivity is one of them and has also been neglected earlier. The early 1990s witnessed the start of first industrialization of major industries. Pharmaceutical industry growth was an exception. A two digit annual growth has made this sector important in the economy. Currently, almost all domestic demand is met with endogenous production except latest innovations and rare cases. Many published articles and news headlines supported the view that the industry has grown faster than others. But the fact is growth in sales does not necessarily mean that the industry is operating efficiently. Authors identified a literature gap. That is, does the industry run in an efficient way? This study analyzed technical efficiency (TEC) of Bangladeshi pharmaceutical industry. We used output-oriented Malmquist index to answer the following questions: a) among the companies who are the major contributors of the total factor productivity growth in Bangladesh from 2009 to 2013? b) how is the trend of technological changes in selected companies over the period covered?

This paper has five sections. The following section describes a brief background of pharmaceuticals industry in Bangladesh. Section III presents the method of the study, data source and model development for the analysis. Section IV addresses major contribution of earlier literature in the above issues. Analysis of empirical results is discussed in section V. Finally, section VI presents conclusion and policy implications.

BACKGROUND OF THE PHARMACEUTICAL INDUSTRY OF BANGLADESH

The progress record of this industry is very pleasing. In 1982, Government of Bangladesh deregulated the Drugs Control Ordinance. It helped local investors to jump into investment. Before that, Bangladesh was completely an import oriented country. Nowadays, roughly 343 pharmaceutical companies are registered to serve a market of USD 1300 million (Hossain, Nur, & Habib, 2014). According to the report of The Dhaka Chamber of Commerce and Industries (DCCI), Bangladesh pharmaceutical industry is self-sufficient in meeting 97% of local demand. Remaining 3% consist of specialized vaccines and anti-cancer products. This industry is now the second largest contributor of national revenue from exporting a wide range of medicine to more than 75 countries around the globe. Most importantly, the industry is dominated by the local companies. Besides creating employment, this promising sector recently attracted foreign investment by offering three main competitive advantages; a) reasonable power cost, b) low labor cost and c) trained employee (white color labor) cost. Since liberation in 1971, in just four decades, a full-fledged industry is now operating with pride.

However, the agreement between Bangladesh and Trade Related Aspects of Intellectual Property Rights (TRIPS) in 2001 prescribes that Bangladesh can enjoy purchase of raw materials without patent fees as the member of Least Development Country (LDC) and World Health Organization (WHO) until 2016. During this period, Bangladesh is also imposed with restricted export facility. Now, a deeper look may find the gravity of requiring an answer to a question, that is, did the industry achieve efficiency? The improvement we saw is not all, indeed. It is important to study the sources of the productivity within the industry. The results from the study would help executives, government and policy makers to reshape their strategies and aid policy decisions.

METHODS

Malmquist total factor productivity (TPI) is used in the study to measure performance of Bangladeshi pharmaceuticals industry. Literally, efficiency measurement begins with the valued work of (Debreu, 1951) where "dead loss" of an economic system was numerically evaluated in a non-optimal economic condition. Later, efficiency was first introduced by (Koopmans, 1957). His definition of technical efficiency explains output maximization capacity keeping input constant or minimizing input keeping output level unchanged. The Malmquist index is used to present efficiency of a DMU over a period of time. Based on the valued work of (Malmquist, 1953), (Caves, Christensen, & Diewert, 1982) and improved the non-parametric framework of Malmquist index. Total factor productivity (TPI) of a firm was first proposed by (Coelli, Rao, O'Donnell, & Battese, 2005). They estimated an index contained with all inputs and outputs of a DMU in ratio format. Non-parametric distance function is used for the calculation. Use of distance function is due to examine the relative status of a DMU in comparison to the optimal DMU at a given set of inputs and outputs. Benefits of using TPI are ability of using multiple outputs and inputs along with no requirement of specifying behavioral objective functions. Compared to "Tornqvist and Fisher" model, TPI does not require input price for productivity calculation. In addition, Byproducts of TPI are technical efficiency change (TEC) and technical change (TCH). Again, TEC can be said as product of scale efficiency (SE) and pure efficiency (PU). These sources of efficiency changes help researchers for examining efficiency from different perspectives. Furthermore, the decomposition of

TPI helps in further modeling and innovation of efficiency analysis. (Fare, Grosskopf, Norris, & Zhang, 1994) demonstrate the use of DEA for calculating TPI index. Based on the CCR ratio, (Banker, Charnes, & Cooper, 1984) examined a model using multiple inputs and outputs in all capacity (Increasing, constant or decreasing return to scale) of firms. Their findings contributed modern economics in farther exploration.

If the input and output vector of a production unit is presented by $x^t and\ y^t$ and (t) stands for time period, the output set of the production process can be defined as:

$$P^t(X^t) = \{Y^t: X^t\ produces\ Y^t\} \tag{1}$$

This output set by Chou, Shao, and Lin (2012) satisfies notion of disposability of inputs and outputs since it assumed to be closed, bounded and convex (Coelli et al., 2005). A distance function for the output set can be designed as follow:

$$D^t(x^t, y^t) = \min\{\theta: (y^t/\theta)\ \in\ P^t(x^t)\} \tag{2}$$

Note that, the input oriented distance function is just the reciprocal of Eq. (2). Again, θ stands as radial factor for adjusting output vector's position. Since the boundary of (x,y) is defined as the set of (θ)= (1,1), Eq. (2) corresponds to BBC (variable returns to scale) models. We can duplicate eq. (2) as a linear programming (LP) converting for a DMU t′

$$\left(D\left(x^{t'}, y^{t'}\right)\right)^{-1} = \max\{\ \lambda: \sum_{t=1}^{T} z^t x^{tn} \leqq x^{t'n}, \quad n = 1 \dots\dots\dots N$$

$$\sum_{t=1}^{T} z^t y^{tm} \geqq xy^{t'm}, \quad m = 1 \dots\dots\dots M$$

$$z^t \leqq 0, t = 1 \dots\dots\dots..T\} \tag{2.1}$$

Here, z^t is the intensity variable.

Considering two consecutive time frames e.g. t and t+1, and combining the distance function of Eq. (2), TPI of Malmquist index can be shown as follow:

$$MI\ (y^t, x^t, y^{t+1}, x^{t+1}) = \left[\frac{D^t(x^{t+1},y^{t+1})}{D^t(x^t,y^t)} \times \frac{D^{t+1}(x^{t+1},y^{t+1})}{D^{t+1}(x^t,y^t)}\right]^{\frac{1}{2}} \tag{3}$$

Eq. (3) can be transformed into;

$$MI = \left[\frac{D^{t+1}(x^{t+1},y^{t+1})}{D^t(x^t,y^t)}\right]\left[\frac{D^t(x^{t+1},y^{t+1})}{D^{t+1}(x^{t+1},y^{t+1})} \times \frac{D^t(x^t,y^t)}{D^{t+1}(x^t,y^t)}\right]^{\frac{1}{2}} \tag{4}$$

Here,

$$Technical\ efficiency\ change\ (TEC) = \left[\frac{D^{t+1}(x^{t+1},y^{t+1})}{D^t(x^t,y^t)}\right] \tag{5}$$

$$Technical\ Change\ (TCH) = \left[\frac{D^t(x^{t+1},y^{t+1})}{D^{t+1}(x^{t+1},y^{t+1})} \times \frac{D^t(x^t,y^t)}{D^{t+1}(x^t,y^t)}\right]^{\frac{1}{2}} \quad (6)$$

$$\text{So, } Malmquist\ TPI = TEC\ \times TCH \quad (7)$$

Output oriented Malmquist TPI Index, as shown above in Eq. (3) can be decomposed as a product of technical efficiency change (TEC) and technical change (TCH) as presented in Eq. (4). Keeping the input vector constant for the period *t*, the distance function explains the major changes until the period *t+1*. Here, D is used as distance function by taking the decision-making unit in the assessment to desired frontier. In Eq. (3), the first part of the ratio $\left(\frac{D^t(x^{t+1},y^{t+1})}{D^t(x^t,y^t)}\right)$ expresses the concept of Catch-Up and the second part $\left(\frac{D^{t+1}(x^{t+1},y^{t+1})}{D^{t+1}(x^t,y^t)}\right)$ denotes Frontier Shift of the DMU from time t to t+1 (Cooper, Seiford, & Tone, 2007, p. 329). The frontier shift assumes the first part as the target benchmark and captures the technical efficiency changes for the following period. In order to calculate productivity changes of a DMU, at least two frontiers must be considered. A value of MI more than one defines productive growth and less than one indicates productivity decline in a given adjacent time. The specialty of MI is it can decompose productivity change of the required frontier into two exclusive components; TEC and TCH (Davamanirajan, Kauffman, Kriebel, & Mukhopadhyay, 2006). Noted that, a value of 1 (one) for all TPI, TEC and TCH explains that the company efficiency remains equal compared to period (t) in (t+1). Again, a value of more than 1 (one) represents improvement and less than 1 (one) explains regress in efficiency as a relative measure.

Further decomposition of TEC, Eq. (5) is shown below:

$$TEC = \left[\frac{D^{t+1}(x^{t+1},y^{t+1})}{D^t(x^t,y^t)}\right]$$

$$= \left[\frac{D_{VRS}^{t+1}(x^{t+1},y^{t+1})}{D_{VRS}^{t}(x^t,y^t)}\right]\left[\frac{D^{t+1}(x^{t+1},y^{t+1})}{D^t(x^t,y^t)} \times \frac{D_{VRS}^{t}(x^t,y^t)}{D_{VRS}^{t+1}(x^{t+1},y^{t+1})}\right] \quad (8)$$

Here, D_{VRS} is the output distance function for variable returns to scale. The first part of the Eq. (8) is named as pure efficiency (PE) that describes pure change in technical efficiency in a relative form of defined consecutive time period. And, remaining part of Eq. (8) stands for describing change in effect due to economics of scale and denoted by SE. Thus,

$$Pure\ efficiency\ Changes\ (PE) = \left[\frac{D_{VRS}^{t+1}(x^{t+1},y^{t+1})}{D_{VRS}^{t}(x^t,y^t)}\right] \quad (9)$$

$$Scale\ efficiency\ changes\ (SE) = \left[\frac{D^{t+1}(x^{t+1},y^{t+1})}{D^t(x^t,y^t)} \times \frac{D_{VRS}^{t}(x^t,y^t)}{D_{VRS}^{t+1}(x^{t+1},y^{t+1})}\right] \quad (10)$$

Combining Eq. (4) and (8), it comes as TPI is the product of TCH, PE and SE. An extended version of Eq. (7) can be then,

$$Malmquist\ TPI = PE \times SE\ \times TCH \quad (11)$$

This study evaluates sources of efficiency changes in pharmaceuticals industry of Bangladesh using TPI. Three inputs have been selected for the analysis namely fixed asset, cost of raw materials and cost of salary and wages with only one output namely sales (both local and export). Data is collected from annual reports published by the companies. Despite having 343 pharmaceuticals firms in the country, this study focuses on all the 14 companies listed in the stock exchange, due to unavailability of data. The study covers data from 2009 to 2013.

LITERATURE REVIEW

The measurement of efficiency in Bangladeshi Pharmaceuticals Industry would be the first of its nature. Past studies are mostly related to pharmaceutical industries covering various factors of production e.g. input, output, constraints etc. Most of the literatures on manufacturing industry have been focused on output-oriented productivity viz. sales. A unit of positive change in output indicates a unit increase in the efficiency of inputs. Thus, reduction of input cost may meet by producing higher level of output. This paper covers the literature only on efficiency, productivity of pharmaceuticals and manufacturing industry and Total Factor Productivity.

Both Azam and Richardson (2010) and Royhan (2013) concentrated on present status and future prospect of Bangladeshi pharmaceutical industry. Their findings have limitation in proper justification of the growth statement and model specification. Saranga and Phani (2004) examined DEA of Indian pharmaceutical companies using data from 44 listed companies. Authors argued that the growth of individual company is independent to its internal efficiency. They suggested for a preparation of being "product patent" rather "process patent". According to them, earlier realization of world scenario in pharmaceutical industry and action plan can save the total industry in case of major external economic and international crisis. Mazumdar and Rajeev (2009) evaluated comparative efficiency of different Indian Pharmaceutical companies. They examined data from 2492 unbalanced firms over a period of 1991-2005. The study has revealed that positive technical efficiency changes have been observed in the companies with large-sized and import orientation of new innovation. Investment in R&D has been found as poorly contributing component in Total Factor of Productivity growth among the selected companies.

Kirigia, Emrouznejad, Sambo, Munguti, and Liambila (2004) analyzed technical efficiency of health organizations in Kenya. Based on the secondary data from 32 major health care centers, DEA has been examined. Their findings have revealed that 44% of total health care center are technically inefficient. Seminal paper of Hashimoto and Haneda (2008) has been examined technical efficiency of Japanese pharmaceutical industry using same technique. They used sales volume as single output and three inputs namely, patent or R&D, product innovation and process innovation cost. Their findings have been summarized a consistent negative productivity change over the period of 1982 to 2001. Recently, Tripathy, Yadav, and Sharma (2013) examined 81 Indian pharmaceutical companies using Malmquist productivity index. A positive technical efficiency change has been observed over the period of the observation. The study has resulted with significant outcomes in determining firm-specific factors of productivity for any pharmaceutical company. For example; age of establishment, Research and development, ownership and foreign direct investment.

Nordin Haji Mohamad and Said (2011) measured efficiency of Government linked Malaysian companies using data from 2003 to 2008. DEA analysis identified only 10 companies in the favorable frontier.

Malmquist index of TPI examined that even though the companies have shown a positive technical efficiency change in the results but did not achieve recommending technological change of new innovations and progress. This study has used Paid-up-capital, Fixed Asset and Total Salary as input and Sales revenue, Return on Asset and Market Price per share as output. A recent work of Ramli and Munisamy (2013) on technical efficiency and ecological efficiency also contributed the existing literature. They applied DEA and Directional Distance Function (DDF) on manufacturing industries over the period of 2001 to 2010. The study has used Operating Expenditure and Capital as input and sales as desirable output. In contrast to the findings of Jajri and Ismail (2007), Ramli and Munisamy (2013) checked the efficiency on state basis rather than sector basis.

Noordin Haji Mohamad and Said (2012)studied on efficiency measurement of 42 world economies on effect of technology innovation had revealed that only best practiced firms can adopt and make use of new technological adoption at higher rate rather than others. Decomposition of TPI also suggested that there was no significant difference in efficiency changes compared to technological innovation in economy. Authors argued that a positive unit TPI change can maximize the level of output and shift the economy at higher frontier. Looking at the size orientation and productivity of firms, Schiersch (2012) filled the gap of size-efficiency relationship studying more than 22,023 observations of German mechanical engineering industry. Study revealed that comparatively small and large companies are efficient ones and medium ones are mostly inefficient. Their findings also suggested that a U-shaped relationship has been observed in case of size-efficiency relationship unlike the simple increasing shape found in earlier studies. Worldwide, a big number of researches have been conducted using DEA to test TPI growth. Mahadevan (2002) tested TPI of Malaysian manufacturing industries from 1981 to 1996. Technical efficiency and scale efficiency have been analyzed and found a positive growth scoring 0.8% annually. Literature supported that this poor change has been driven by technological changes. Din, Ghani, and Mahmood (2007) examined the efficiency of Pakistani large-scale manufacturing industry. They used both parametric and non-parametric frontier techniques. They covered data between 1995 and 2001. Only a little increase in efficiency level has been observed in both results. The study used Capital and Labor as input and Industrial and non-industrial cost as output. Here, industrial cost explains operating cost and Non-industrial cost contains intangible and non-operating costs.

Overtime, a growing concern has been observed in Total Factor Productivity growth calculation for efficiency measurement. Kartz (1969) argued that technological changes and innovation have a significant role in productivity changes. His study covered TPI in Argentina over the period of 1946 to 1961 and identified improvement in labor productivity in manufacturing sector. Jajri and Ismail (2007) calculated the efficiency of Malaysian manufacturing sector over a period of 1985 to 2000 using Data Envelopment Analysis (DEA) technique with two inputs; labor and capital expenditure (Fixed Asset), and a single output i.e. value added sales price. Their findings suggested that technical efficiency is the major contributor in Total Factor Productivity. An upward trend of technological change was also highlighted except in the textile industry. Most of the empirical studies on efficiency management have revealed that efficiency of pharmaceuticals industry is in positive relation with size, good governance, technological innovation and business nature (Anesary et al., 2014; Mazumdar & Rajeev, 2009; Saranga & Phani, 2004). Poor relationship has been identified between geographical region, model of analysis, time frame and efficiency (Azam & Richardson, 2010; Centre, 2007; Hossain et al., 2014). In line with this, present study attempts to explore the case of Bangladeshi Pharmaceuticals industry.

RESULTS AND DISCUSSION

Table 1 and 2 explain efficiency scores of all 14 selected pharmaceutical companies over the period 2009 to 2013. Based on Malmquist index analysis proposed by (Fare et al., 1994), productivity of a decision making unit is evaluated based on the value of one. A value more than unity explains the positive TPI growth of that decision making unit (DMU) for the time (t+1) compared to time (t).

Table 1: Malmquist index summary of annual means (2009- 2013)

year	TEC	TCH	PE	SE	TPI
2009	0.944	1.266	1.022	0.924	1.196
2010	0.761	1.347	0.926	0.822	1.024
2011	0.877	1.151	0.755	1.161	1.009
2012	1.427	0.696	1.319	1.081	0.994
2013	0.838	1.225	0.954	0.879	1.027
mean	0.9694	1.137	0.9952	0.9734	1.050

Table 1 represents a summary of annual means of Technical Efficiency Change, Technological Change, Pure Technical Efficiency Change, Scale Technical Efficiency Change and Total Factor Productivity (TPI) Change for all 14 companies. It is seen from the table that all the companies have inefficiency within a range of 5.6% to 23.9% in case of Technical Efficiency Change throughout the study period except for the year 2012. In case of Technological Change, all companies have experienced a negative efficiency of 31.4% in the same year. Compared to other years, this deficiency is a major breakdown. Even though, in the following year, companies have restored the capacity and had a 22.5% upward TPI growth. Turning to pure technical efficiency; companies have experienced a positive growth change in 2009 and 2012. In remaining years, negative efficiency within a range of 4.6% to 24.5% has been witnessed in the table. A similarly mixed result has also been observed in case of Scale Efficiency Change of the companies over the study period. Looking at the means, the main source of technical inefficiency in pharmaceutical industry is scale inefficiency rather than pure technical inefficiency. In total, the Total Factor Productivity (TPI) growth of the companies found to be positive except for the year 2012 and within a range of -0.6% to +19%. The overall TPI growth change of the companies is in the order of 4.7% over the study period.

Figure 1 depicts the line graph of technical efficiency, technological change and total factor productivity (TPI). The most noticeable criteria are TEC and TCH have followed an inverse pattern throughout the study period. It is also highlighted here that for both of the trends, the most disruption is occurred in the year 2012. In aggregate, a regress in TPI is observed from 2009 to 2012 mainly due to consistent fall in TCH. Results of table 1 present a significant influence of TCH over TPI.

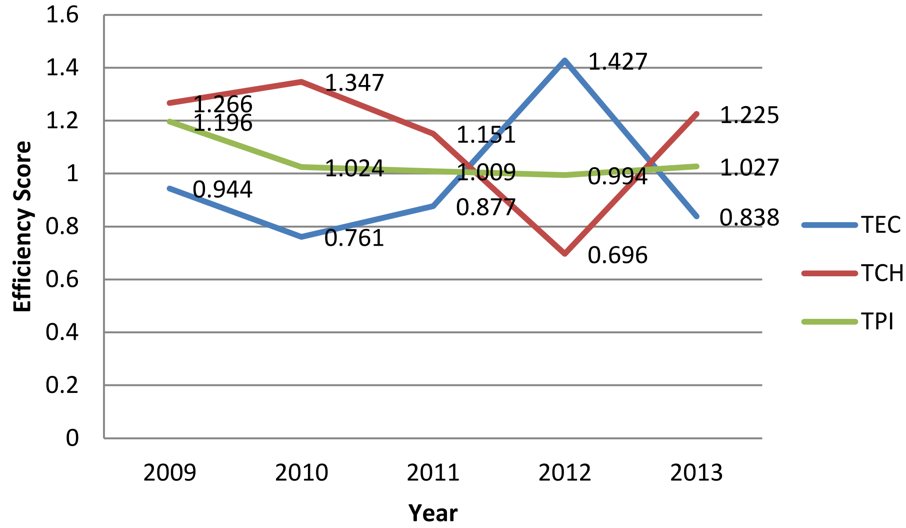

Figure 1: Changes in TEC, TCH and TPI over the study period (2009-2013)

Figure 1 depicts the line graph of technical efficiency, technological change and total factor productivity (TPI). The most noticeable criteria are TEC and TCH have followed an inverse pattern throughout the study period. It is also highlighted here that for both of the trends, the most disruption is occurred in the year 2012. In aggregate, a regress in TPI is observed from 2009 to 2012 mainly due to consistent fall in TCH. Results of table 1 present a significant influence of TCH over TPI. Similar research on MI and TPI of (Ahn & Min, 2014; Arjomandi, Valadkhani, & O'Brien, 2014) explain the attachment of TCH with macroeconomic factors e.g. government policy or restrictions, country specific issues and financial stability and advancement in technology within the industry. Results from the table 1 explain an opportunity of further improvement in TPI is attached with the degree of adoption capacity of the industry with macro-economic external business environment and changes. Moreover, Bangladesh has faced some economic slowdown in mid of 2012 (Aziz, Janor, & Mahadi, 2013). It is of course a matter of discussion that what factors may effect on technological changes and by how much?

Table 2 reveals a nutshell of Malmquist Index Summary of Firm Means which is based on geometric means over a period of 2009 to 2013. As noted previously, the TPI of all companies observed a positive growth of 4.7% annually. This change could be higher if Technical Efficiency Change of companies were somewhere in unit value or positive values. On average, a total 5.5% negative efficiency has been seen in Technical Efficiency Change of all companies annually. ACI, GLAXOSMITH and RENATA had unit efficiency change annually. Only RECKITTBEN had a positive Technical efficiency change with a value of 3.3% annually among the companies. A total of 9 (nine) companies, however, experienced a positive change in technological efficiency with a range of 5.3% to 36% annually. And 5 (five) companies namely AMBEEPHA, CENTRALPHL, MARICO, ORIONPHARM and RECKITTBEN have been found inefficient over the study period. Considering Technological change, all the companies have scored, on an average, 10.8% positive growth annually. Inefficiency has been observed in both pure technical efficiency and scale efficiency scoring of about 3% annually. Based on the findings, it is to be recorded that a total of 9 companies have been observed with positive Total Factor Productivity (TFP) growth changes. Among them, ACI, GLAXOSMITH and RENATA have been found top ranked. Remaining 5 companies have scored negatively in TPI change with a range of -1.1% to 28.6% annually. The lowest and highest TPI changes have been observed for AMBEEPHA and ACI respectively.

Table 2: Malmquist index summary of firm means (2009- 2013)

Firm	TEC	TCH	PE	SE	TPI
ACI(ACI Limited.)	1.000	1.360	1.000	1.000	1.360
AMBEEPHA(Ambee Pharma)	0.917	0.778	0.993	0.923	0.714
BEACONPHAR(Beacon Pharma. Ltd.)	0.866	1.358	0.880	0.984	1.176
BXPHARMA(Beximco Pharma)	0.936	1.214	1.000	0.936	1.136
CENTRALPHL(Central Pharma. Ltd.)	0.939	1.053	0.963	0.975	0.989
GLAXOSMITH(Glaxo SmithKline)	1.000	1.300	1.000	1.000	1.300
IBNSINA(The Ibn Sina)	0.940	1.180	0.941	1.000	1.110
LIBRAINFU(Libra Infusions Limited)	0.976	1.085	0.984	0.992	1.059
MARICO(Marico Bangladesh Limited)	0.917	0.855	0.993	0.923	0.784
ORIONPHARM(Orion Pharma Ltd.)	0.878	1.075	0.915	0.959	0.943
PHARMAID(Pharma Aids)	0.932	1.128	1.000	0.932	1.051
RECKITTBEN(Reckitt Ltd.)	1.033	0.951	1.054	0.980	0.982
RENATA(Renata Ltd.)	1.000	1.245	1.000	1.000	1.245
SQURPHARMA(Square Pharma. Ltd.)	0.915	1.123	1.000	0.915	1.028
Geometric Mean	**0.945**	**1.108**	**0.979**	**0.965**	**1.047**

The geometric mean of TEC, PE and SE has significance. In this part we will highlight the main sources of inefficiency in pharmaceutical industry. As discussed earlier, TEC can be decomposed into PE and SE. In table 2, 2.1% of overall pure inefficiency is described by the overall technical inefficiency of 5.5%. This surely means that the internal management of the selected companies is responsible for such inefficiency. And the remaining inefficiency of TEC is described by scale efficiency which means there is a possibility of been performing inefficiency just because of sub-optimal scale size. Out of 14 firms, equal numbers of firms are in best practice frontier and in inefficient area. In case of SE, a value of 1 denotes company's presence in the line of long term average cost curve. SE value of less than one explains the firms' inability of run with appropriate size and direct relation with technical inefficiency. Among the 14 firms, only 3 (three) companies are in most productive scale size scoring with value with one. Remaining companies have scale inefficiency from a range of .08% to 8.5%.

CONCLUSIONS

This study has contributed the literature by filling a gap between the knowledge of existing industry growth and its true productivity. The findings have indicated an average positive productivity change in Bangladeshi pharmaceutical industry over the study period from 2009 to 2013. Results from the model explain the marginal productivity improvement is only due to technological changes of the industry through the adoption and development of new technological aspects within the companies. The overall technical efficiency has regressed. The decline in efficiency is likely to be due to the widening of the efficiency gap among pharmaceutical with less efficient companies moving further away from the frontier. The reasons for the increased dispersion of performance are not apparent but may indicate several things. The dispersion may be due to the strong influence of external environment e.g. in 2012, there was political unrest in Bangladesh; export limitations imposed by TRIPS; barriers to diffusion of innovation and the absence of successful mergers and acquisitions among the inefficient companies. The latter indicates that efficient reorganization is not taking place in the industry.

It is seen that a majority of the big pharmaceutical companies in Bangladesh are experts in process patent activities rather in product patent. Such industry condition can easily generate higher profile in production and sales. However, achieving sustainability in long run using automation and purchase of patent may not be possible. In over the last two decades, it is found that both medium and big size companies have leaned on introducing automation in their existing product plants, improving them in nothing but production. Even though, with such increase of production and sales, the cost for production did not change significantly. Apart from this, Bangladesh can only enjoy the special facility on raw materials import at reduced price until 2016. Post 2016, Bangladesh must pay at least 40% extra compared to the present cost for this purpose. Existing literature supports that only two companies have been investing on research and development on patent development and raw material production. Major researches show that establishing sustainability and productivity of pharmaceutical companies depend on “Product Patent” rather than “Process Patent”. Without establishing self-dependency on production and innovation of raw materials, this bright manufacturing sector may face absolute shock in next short time.

The convergence of efficiency towards the frontier can be achieved by learning the practices of peer units, strengthening incentive schemes to improve efficiency, controlling the reorganization of the industry, removing barriers to exporting, and stimulating research and innovation.

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