Article

Productivity Changes of Pharmaceutical Industry in Bangladesh: Does Process Patent Matter?

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Abstract

The large pharmaceutical companies in Bangladesh have currently expertise in process patent activities rather than in product patent. Such industry condition can easily generate a high profile in production and sales. However, achieving sustainability in the long run using automation and purchase of the patent only seems unsuitable. In the last two decades, it is found that both the medium and big size companies have leaned on introducing automation in their existing product plants, improving them in nothing but production. The article measures technical efficiency using data envelopment analysis (DEA) over the period of 2009–2013. We use one output—annual sales—and three inputs, namely, (a) fixed asset, (b) raw material cost and (c) cost of salary to run Malmquist total factor productivity (TFP) index. The major contributor of TFP growth is found due to the technological positive growth with a value of 10.8 per cent annually. Moreover, all changes of technical efficiency, pure efficiency and scale efficiency have regressed with values of 5.5 per cent, 2.1 per cent and 3.5 per cent, respectively. Thus, the gains in productivity are entirely due to technological advancements and not for technical improvements. The main source of inefficiency in pharmaceutical industry is scale inefficiency rather than pure technical inefficiency. Limitations and policy implications are addressed.

Keywords

Efficiency, data envelopment analysis, Malmquist productivity index, pharmaceutical

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Introduction

Since independence in 1971, Bangladesh has been facing multidimensional challenges in the way to its economic development. Ensuring productivity is one of them and has also been neglected earlier. The early 1990s has witnessed the start of first industrialization in major industries. Among them, pharmaceutical industry's 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. But the fact is growth in sales does not necessarily mean that the industry is operating efficient. Authors identified this literature gap: does the pharmaceutical industry of Bangladesh run in an efficient way?

This article measures the productivity in Bangladeshi pharmaceuticals industry which is, to the best of authors' knowledge, the very first from Bangladesh perspective. Earlier studies have mostly examined pharmaceutical industries covering various factors of production, for example, input, output, constraints and so on. Most of the literatures on manufacturing industry have been focused on output-oriented productivity, namely, sales. Efficiency is a relative measure of decision-making units' (DMUs) performances. 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 article utilizes the Malmquist data envelopment analysis (DEA)—the most popular non-parametric approach of productivity measurement in contemporary literature (Azad, 2015; Azad, Masum, Munisamy & Sharmin, 2015; Kamarudin, Nordin, Muhammad & Hamid, 2014; Sufian & Habibullah, 2010; Wanke, Azad & Barros, 2016).

This article is divided into seven sections. The second section describes a brief review of literature. The third section states main objectives of this article. The fourth section presents the rationale of this study. Methodology, data source and model development for the analysis are presented in the fifth section. The sixth section critically evaluates the results and analysis, with major contribution of earlier literatures in the above issues. The seventh section presents conclusion and policy implications.

Literature Review

Literature on productivity analysis in Bangladesh context is very limited (Azad, 2015). Among the recent ones, 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 2,492 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 productivity (TFP) growth among the selected companies.

Among the similar studies, Kirigia, Emrouznejad, Sambo, Munguti and Liambila (2004) analysed technical efficiency of health organizations in Kenya. Based on the secondary data from 32 major

healthcare centres, DEA has been examined. Their findings have revealed that 44 per cent of total healthcare centres 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. Mohamad and Said (2011) measured efficiency of government-linked Malaysian companies using data from 2003 to 2008. The DEA identified only 10 companies in the favourable frontier. Malmquist index of TFP examined that even though the companies have shown a positive technical efficiency change in the results but did not achieve recommended 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 to the existing literature. They applied DEA and directional distance function (DDF) on manufacturing industries over the period of 2001–2010. 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.

Among the worldwide studies, 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 TFP also suggested that there was no significant difference in efficiency changes compared to technological innovation in economy. Authors argued that a positive unit TFP 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 had 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 TFP growth. Mahadevan (2002) tested TFP of Malaysian manufacturing industries from 1981 to 1996. Technical efficiency and scale efficiency have been analysed and found a positive growth scoring 0.8 per cent 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 labour 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.

Over time, a growing concern has been observed in TFP growth calculation for efficiency measurement. Kartz (1969) argued that technological changes and innovation have a significant role in productivity changes. His study covered TFP in Argentina over the period of 1946 to 1961 and identified improvement in labour productivity in manufacturing sector. Jajri and Ismail (2007) calculated the efficiency of Malaysian manufacturing sector over a period of 1985 to 2000 using DEA technique with two inputs—labour and capital expenditure (fixed assets)—and a single output, that is, value added

sales price. Their findings suggested that technical efficiency is the major contributor in TFP. 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 (Mazumdar & Rajeev, 2009; Saranga & Phani, 2004). Poor relationship has been identified between geographical region, model of analysis, time frame and efficiency (Azam & Richardson, 2010; International Trade Centre, 2007; Masum, Azad, Hoque & Beh, 2015; Rahman & Azad, 2015). In line with this, present study attempts to explore the case of Bangladeshi pharmaceuticals industry.

Objectives

The main objective of this article is to analyse technical efficiency of Bangladeshi pharmaceutical industry using an output-oriented Malmquist index to answer first, among the pharmaceutical companies which are the major contributors of the TFP growth in Bangladesh from 2009 to 2013 and second, how is the trend of technological changes in selected companies over the period covered?

Rationale of this Study

Nowadays, roughly 269 pharmaceutical[1] companies are registered to serve a market of $1300 million (Anesary et al., 2014). According to the report of The Dhaka Chamber of Commerce and Industries (DCCI), Bangladesh pharmaceutical industry is self-sufficient in meeting 97 per cent of local demand. Remaining 3 per cent consists 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. Based on these facts, Anesary et al. (2014) argued that Bangladesh has built a strong baseline and going forward can achieve the self-sufficiency for the production of medicine. 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 labour cost and (c) trained employee (white collar labour) 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 a member of Least Development Country (LDC) and World Health Organization (WHO) until 2033. During this period, Bangladesh is also imposed with restricted export facility.

Hence, an in-depth analysis is required to answer a question, that is, how efficient is the industry The improvement we saw is not all, indeed. It is important to study the sources of the productivity within the industry. The results from this study will help executives, government and policymakers to reshape their strategies and aid policy decisions.

The rationale of using DEA with Malmquist technology has twofold benefit. First, DEA is a non-parametric linear model which recently gets attention from researchers and practitioners in all areas of research (Charnes, Cooper, Lewin & Seiford, 1994; Liu, Lu, Lu & Lin, 2013, p. 3). Second, DEA technology has quite a number of good features over using the parametric tests (e.g., stochastic frontier approach). Golany and Storbeck (1999) listed that DEA has been becoming the favourite statistical tool for the following reasons:

- capacity of identifying inefficiency among the examined DMUs
- ability to rank DMUs according to the performance
- evaluate management capacity among the DMUs
- resource allocation using quantitative results
- DEA can examine multiple inputs and multiple outputs at a time.

Methodology—Data, Sample and Empirical Model

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 satisfies notion of disposability of inputs and outputs since it is assumed to be closed, bounded and convex (Coelli, Rao, O'Donnell & Battese, 2005). The linear programming (LP) converting for the above function is shown as follows:

$$\begin{aligned} &(D(x^{t'}, y^{t'}))^{-1} = \max \lambda : \sum_{t=1}^{T} z^t x^{tn} \leqq x^{t'n}, \quad && n = 1, \ldots, N \\ &\sum_{t=1}^{T} z^t y^{tm} \geqq x y^{t'm}, && m = 1, \ldots, M \\ &z^t \leqq 0, && t = 1, \ldots, T \end{aligned} \tag{2}$$

Here, z^t is the intensity variable.

Considering two consecutive time frames, for example, t and $t + 1$, and combining the distance function of Equation (2), TFP of Malmquist index can be shown as follow:

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

Eq. (3) can be transformed into:

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

here,

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

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

$$So, \ Malmquist \ TFP = TEC \times TCH \tag{7}$$

Output oriented Malmquist TFP Index, as shown above in Equation (3) can be decomposed as a product of technical efficiency change (TEC) and technical change (TCH) as presented in Equation (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 DMU in the assessment to desired frontier. In Equation (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 TFP that is more than 1 defines productive growth and less than 1 indicates productivity decline in a given adjacent time. The specialty of TFP is it can decompose productivity change of the required frontier into two exclusive components: TEC and TCH (Davamanirajan, Kauffman, Kriebel & Mukhopadhyay, 2006). Note that a value of 1 (one) for all TFP, 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, Equation (5) is shown below:

$$TEC = \left[\frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)}\right] = \left[\frac{D^{t+1}_{VRS}(x^{t+1}, y^{t+1})}{D^t_{VRS}(x^t, y^t)}\right]\left[\frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \frac{D^t_{VRS}(x^t, y^t)}{D^{t+1}_{VRS}(x^{t+1}, y^{t+1})}\right] \tag{8}$$

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

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

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

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

$$Malmquist\ TFP = PE \times SE \times TCH \tag{11}$$

This study evaluates sources of efficiency changes in pharmaceuticals industry of Bangladesh using TFP. 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. This study focuses on the total population of 14 out of 14 listed companies from Dhaka stock exchange. This study covers data from 2009 to 2013. Summary statistics of the selected variables is shown in Table 1.

Table 1. Summary Statistics, 2009–2013

Variables (in million $)	Min	Max	Mean	Variation Coef.
Input (X_i)				
X_1: Fixed assets	253	18236	753.50	432.61
X_2: Cost of raw materials	196	15201	385	255.62
X_3: Salary expenses	36	89.50	43.50	3.23
Output (Y_i)				
Y_1: Total Sales	985	12041	2364	40.49

Source: Prepared by the authors.

Analysis

Tables 2 and 3 explain efficiency scores of all 14 selected pharmaceutical companies over the period 2009 to 2013. Based on Malmquist index analysis proposed by (Fare, Grosskopf, Norris & Zhang, 1994), productivity of a decision-making unit is evaluated based on the value being less than or greater than 1. A value more than unity explains the positive TFP growth of that decision-making unit (DMU) for the time (t + 1) compared to time (t).

Table 2 represents a summary of annual means of technical efficiency change, technological change, pure technical efficiency change, scaled technical efficiency change and TFP change for all 14 companies. It is seen from the table that all the companies have inefficiency within a range of 5.6 per cent to 23.9 per cent 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 per cent in the same year. Compared to other years, this inefficiency is a major breakdown. This is the case of companies that in 2013 recovered their capacity showing a 22.5 per cent upward TCH 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 per cent to 24.5 per cent 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 TFP growth of the companies was found to be positive except for the year 2012 and within a range of –0.6 per cent to +19 per cent. The overall TFP growth change of the companies is in the order of 4.7 per cent over the study period.

Figure 1 depicts the line graph of technical efficiency, technological change and TFP. The most noticeable criteria are TEC and TCH have followed an inverse pattern throughout the study period. It is

Table 2. Malmquist Index Summary (2009–2013)

Year	TEC	TCH	PE	SE	TFP
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	0.995	0.973	1.050

Source: Authors' calculations.

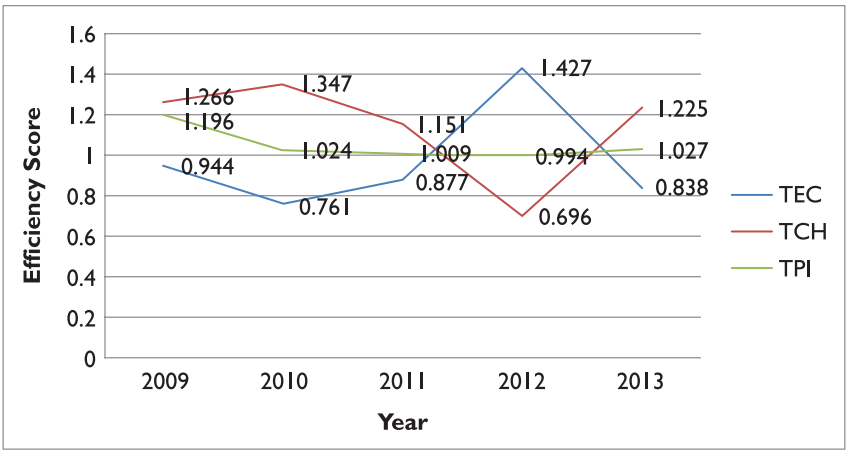

Figure 1. Changes in TEC, TCH and TFP Over the Study Period (2009–2013)

Source: Authors' own findings.

also highlighted here that for both of the trends, the most disruption occurred in the year 2012. In aggregate, a regress in TFP is observed from 2009 to 2012 mainly due to consistent fall in TCH. Results of Table 1 present a significant influence of TCH over TFP.

Figure 1 depicts the line graph of technical efficiency, technological change and TFP. 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 occurred in the year 2012. In aggregate, a regress in TFP is observed from 2009 to 2012 mainly due to consistent fall in TCH. Results of Table 1 present a significant influence of TCH over TFP. Similar research on MI and TFP of Ahn and Min (2014), Arjomandi, Valadkhani and O'Brien (2014) explain the attachment of TCH with macroeconomic factors, for example, government policy or restrictions, country specific issues and financial stability and advancement in technology within the industry. Results from Table 2 explain that an opportunity for further improvement in TFP is attached with the degree of adoption capacity of the industry with macroeconomic external business environment and changes. Moreover, Bangladesh has faced some economic slowdown in mid-2012 (Aziz, Janor & Mahadi, 2013). It is of course a matter of discussion that what factors may effect technological changes and by how much?

Table 3 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 TFP of all companies observed a positive growth of 4.7 per cent annually. This change could be higher if technical efficiency changes of companies were somewhere in unit value or positive values. On average, a total 5.5 per cent negative efficiency has been seen in technical efficiency changes 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 per cent annually among the companies. A total of nine companies, however, experienced a positive change in technological efficiency with a range of 5.3 per cent to 36 per cent annually. And 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 per cent positive growth annually. Inefficiency has been observed in both pure technical efficiency and scale efficiency scoring of about 3 per cent annually. Based on the findings, it is to be recorded that a total of nine companies have been observed with positive

Table 3. Malmquist Index Summary (2009–2013)

Firm	TEC	TCH	PE	SE	**TFP**
ACI	1.000	1.360	1.000	1.000	1.360
AMBEEPHA	0.917	0.778	0.993	0.923	0.714
BEACONPHAR	0.866	1.358	0.880	0.984	1.176
BXPHARMA	0.936	1.214	1.000	0.936	1.136
CENTRALPHL	0.939	1.053	0.963	0.975	0.989
GLAXOSMITH	1.000	1.300	1.000	1.000	1.300
IBNSINA	0.940	1.180	0.941	1.000	1.110
LIBRAINFU	0.976	1.085	0.984	0.992	1.059
MARICO	0.917	0.855	0.993	0.923	0.784
ORIONPHARM	0.878	1.075	0.915	0.959	0.943
PHARMAID	0.932	1.128	1.000	0.932	1.051
RECKITTBEN	1.033	0.951	1.054	0.980	0.982
RENATA	1.000	1.245	1.000	1.000	1.245
SQURPHARMA	0.915	1.123	1.000	0.915	1.028
Geometric Mean	**0.945**	**1.108**	**0.979**	**0.965**	**1.047**

Source: Authors' calculations.

TFP growth changes. Among them, ACI, GLAXOSMITH and RENATA have been found top ranked. Remaining five companies have scored negatively in TFP change with a range of −1.1 per cent to 28.6 per cent annually. The lowest and highest TFP changes have been observed for AMBEEPHA and ACI, respectively.

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 per cent of overall pure inefficiency is described by the overall technical inefficiency of 5.5 per cent. 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 performing inefficiently just because of suboptimal 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 1 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 1. Remaining companies have scale inefficiency from a range of 0.08 per cent to 8.5 per cent.

Robustness Analysis

The significance of the derived data from DEA calculation is now tested for both the groups of data (product patent and process patent). Coakes and Steed (2003) demonstrated that with an even sample distribution, Mann–Whitney test is the relevant test. Along with parametric test (t-statistics), this Mann–Whitney test will be suitable to test the robustness of obtained results in earlier section.

Table 4 shows the robustness test's results. The parametric *t*-test result reveals that in terms of quality indicator, process patent firms are indicating higher efficiency than that of product patent firms ($0.371 < 0.952$). A similar finding is also confirmed by the result obtained from the non-parametric test of Mann–Whitney and the Kruskall–Wallis test which are significant in either 1 per cent or 5 per cent level.

Table 4. Robustness of Data and Results

	Parametric test		Non-parametric tests		
	t-test		Mann–Whitney test		Kruskall–Wallis test
	t(prb > *t*)			*z*(prb > *z*)	X^2(prb > X^2)
Test statistics	Mean	*t*	Rank Score	*z*	X^2
Total productivity index					
Process patent	0.952	–2.876***	58.54	–1.751**	3.362***
Product patent	0.371		49.36		

Source: Authors' own findings.
Note: ** and *** indicate significance level at the 5% and 1% levels, respectively.

Conclusions

This study has contributed to 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 that 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 companies, 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, for example, 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 than in product patent. Such an 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 per cent 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 a short period of time.

Managerial Implications

The key managerial implications of this article are threefold: First, managers of production industries (pharmaceutical industry in this article) in Bangladesh can use this research as a tool to critically examine whether process patent or product patent can bring maximum benefit towards their companies. Second, the policy makers from all perspectives (i.e., national level, industry level and individual level) thus get a dot for discrimination among the industry objectives. Literally, developing countries like Bangladesh need more product patents for smooth growth of the economy compared to process patents (Azam & Richardson, 2010; Tripathy et al., 2013). Last but not least, managers from pharmaceutical industries in Bangladesh can take innovative steps for improving existing pure efficiency and scale efficiency since the major contributor of current TFP growth is found to be the technical efficiency.

Limitations and Future Research

The major limitation here is related to data availability. Further in-depth analysis is suitable using meta-frontier technology to see the effect of heterogeneity. Introduction of undesirable output will also increase the robustness of the study. 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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Note

1. The list can be retrived from http://www.dgda.gov.bd/index.php/2013-03-31-05-16-29/drug-manufacturers/allopathic accessed on 25.07.16. This article considers only allopathic drug manufacturers in Bangladesh context.

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