Journal of Peace, Development and Communication

PEACE AND DEVELOPMENT

Volume 04, Issue 3, October-December 2020
pISSN: 2663-7898, eISSN: 2663-7901
Article DOI: https://doi.org/10.36968/JPDC-V04-I03-14
Homepage: https://pdfpk.net/pdf/
Email: se.jpdc@pdfpk.net

Abstract

Article:	**The Pharmaceutical Firms of Pakistan: An Overview of Multidimensional Performance**
Author(s):	Dr. Majid Ali Assistant Professor, Department of Economics, PMAS-ARID Agriculture University, Rawalpindi
	Dr. Ghulam Sarwar Assistant Professor, Noon Business School, Faculty of Social Sciences, University of Sargodha
	Dr. Abdul Saboor Professor/Dean of Social Sciences, Department of Economics, PMAS-ARID Agriculture University, Rawalpindi
Published:	30th December 2020
Publisher Information:	Journal of Peace, Development and Communication (JPDC)
To Cite this Article:	Ali, Majid, et al. (2020). "The Pharmaceutical Firms of Pakistan: An Overview of Multidimensional Performance." *Journal of Peace, Development and Communication*, vol. Volume 4, no. Issue 3, 2020, pp. 251–266, https://doi.org/10.36968/JPDC-V04-I03-14
Author(s) Note:	Dr. Majid Ali is serving as Assistant Professor at Department of Economics, PMAS-ARID Agriculture University, Rawalpindi Email:majid.uos@gmail.com
	Dr. Ghulam Sarwar is serving as Assistant Professor at Noon Business School, Faculty of Social Sciences, University of Sargodha
	Dr. Abdul Saboor is serving as Professor/Dean of Social Sciences at Department of Economics, PMAS-ARID Agriculture University, Rawalpindi

Abstract

The pharmaceutical industry of Pakistan is now meeting around 80% of total domestic demand with an annual11% growth rate. But the question arises as to whether the firms produce efficiently? The paper measures cost efficiency of the pharmaceutical industry of Punjab using Data Envelopment Analysis (DEA) for the period of 2014-15. The factors affecting the cost efficiency is also determined by using Tobit method. In first stage, value added is used as single output and number of employs, raw material, and cost of salary are as inputs. The result suggested that the cost efficiency of the pharmaceutical firms is 27.7% which is determined by 46% technical efficiency (TE) and 60.8% allocative efficiency (AE). It means wastage of resources is cost increasing factors in these firms. In the second stage, among the variables i.e. firm's market share, firm's Herfindahl-Hirschman Index (HHI) of market concentration, values of assets, energy, Herfindahl-Hirschman Index has strong positive effect on cost efficiency.

Keywords: DEA; Value added; OLS; Herfindahl-Hirschman Index

Introduction

Pakistan's economy has suffered a great deal over recent years because of poor economic conditions as well as the war on terrorism. In addition, domestic inflation, sluggish economic growth and a large devaluation of the rupee against major currencies were also seen in the economy. No doubt that the government is taking the necessary steps to come out of this worst situation, but it lacks the urgency and also across the board adjustments for the uplift of the economy.

Pakistan's pharmaceutical industry is rapidly growing and benefiting the national economy. Let us see the situation on a global level before we look at the overview of the Pakistan Pharmaceutical industry. The global pharmaceutical industry as a whole is projected at US$650 billion, with a growth rate of 8% annually. In terms of monetary value, the size of the pharmaceutical industry in Pakistan is $3.10 billion (Rs. 325, 596 billion, as per IMS. With over $1 trillion projected for the global pharmaceutical industry, Pakistan is almost 0.5% of the market. Value-based governance for the global economy comprises 48%, 28%, and 12% of the USA, the EU and Japan. (Abrol, et al., 2017).

In Pakistan it's highly competitive and challenging with respect to the pharmaceutical industry. There are 225 such enterprises in operation, some 759 pharmaceutical enterprises are operating in Pakistan. Looking back on Pakistan's pharmaceutical industry, it is clear that the image has changed entirely. There was a scenario in the early 90s that the MNCs dominated Paquistan Pharmaceutical Industry, but in the last 18 years or so, the image of the 386 operating powers, 30 being MNCs that manufacture drugs, has changed entirely. The ratio between MNCs and domestic businesses is now 45% and 55%, respectively. For local investors, it is an encouraging sign

Looking back on Pakistan's pharmaceutical industry, it is clear that the image has changed entirely. There was a scenario in the early 1990s that the MNCs had occupied

Pakistan's pharmaceutical industry, but the image has totally changed over the last 18 years or so. Of the 386 operating units, thirty are MNCs that produce narcotics. The ratio between MNCs and domestic businesses is now 45% and 55%, respectively. The fact that the share of national firms is rising is a good sign for local investors. Pakistan's pharmaceutical industry today accounts for a total volume of US$ 1.64 billion, with an annual increase of 11% more than the global growth of the Pharmaceutical industry.

In the current situation, with the take-over of national firms, roughly 80% of domestic needs are met, while 20% are imported. Far from China, India, Europe, North America and other countries all raw materials are imported. Approximately 20 percent of total imports produced come from Switzerland. The 10th largest pharmaceutical market in Asia Pacific, the Philippines as well as Vietnam is Pakistan. Many newspaper articles and headlines have shown that the pharmaceutical industry in Pakistan is rising faster than other countries. The truth is, however, that growth in revenue does not necessarily indicate an efficient company. A literature gap was defined by writers. In the present case, the acquisition of national companies meets approximately 80% of national needs and 20% is imported. All raw materials are imported away from China, India, Europe, North America and other nations. Around 20% of the total imports produced originate in Switzerland. In Asia Pacific, the Philippines and Vietnam, Pakistan is the 10th largest market in pharmaceuticals. Many papers and headlines have proven to be quicker than other countries for pharmaceutical industry in Pakistan. However, the fact is that sales growth does not inherently imply a profitable business. Writers have identified a literature gap. Does the industry work effectively? This study examined the pharmaceutical industry's cost efficiency (CE). To assess efficiency the study used input-oriented data creation analysis. The cost efficiency factors are also calculated with the Ordinary Least Square (OLS) process. Geographical distribution of pharmaceutical firms across Pakistan. Provincial pharmaceutical units tend to focus on major

cities such as Karachi, Lahore, and Peshawar. The numbers reflect the fact that most businesses are based in Punjab province. This study therefore focuses on Punjab's pharmaceutical companies' economic performance.

In Punjab Pharmaceutical Industry, performance measurement will be the first of its kind. In different sectors of the Pakistani economy, there is also very little use of the performance calculation approach. Saranga and Phani (2004) checked DEA from Indian pharmaceutical companies by means of information from 44 companies listed in the literature relating to the pharmaceutical industry. The authors argued that individual corporations' growth is independent of their internal productivity. They proposed that "product patent" be prepared instead of "process patent." They suggest that previously implementing the pharmaceutical environment scenario and the action plan will save the industry. The comparative effectiveness of various Indian pharmaceutical firms is assessed by Mazumdarand Rajeev (2009). Data from 2492 unequalled companies for 1991-2005 have been analysed. The study showed that there have been positive improvements to technological efficiency in large and import-focused businesses. The selected companies have found R&D expenditure to be poorly involved in the Total Factor for Productivity growth. The technological efficiency of Japanese Pharmaceutical Industries using the same technique has been reviewed in Hashimoto and Haneda (2008). As single output and three inputs, patent or R&D, product invention and the expense of process innovation, they used revenue volumes. They sum up a clear change in productivity from 1982 to 2001. In decomposition of Malmquist into three categories (Quality Change, Technological Change and Efficiency Change), Fareset et al. (1995) analysed Swedish pharmaceuticals firms. The effect of technological expertise upon company success of global pharmaceutical companies was examined by Carolis (2003). Danzon et al (2005), using different econometric models to analyse the effect of experience and partnership in the pharmaceutical industry. The Spanish

pharmaceutical industry, Gonzalez and Gascon (2004), studied the Bcc DEA model, and identified a substantial contribution to productive growth of technical efficiency. It also states that in the case of big, medium and small businesses, the effect of technological efficiency on productivity improvements was different.

Methodology

In 1978 Charnes, Cooper and Rhodes initially developed a Data Envelopment Analysis (DEA) study based on Farrell's pioneering work in the field of efficiency (Farrell, 1957), and thus the CCR template. DEA is the programming method of the mathematical line which produces a single efficiency measure for each unit compared to its peers. DEA assesses the performance of organisations such as businesses, colleges, hospitals and banks where comparisons are difficult with multiple inputs and outputs (El-Mashaleh et al., 2010). The organisation assessed by DEA is referred to as decision-making units (DMUs). In this analysis, the DMUs refer to 86 pharmaceutical companies which are responsible for transforming inputs (i.e. energy, money, etc.) into outputs (i.e., sales and profits). The DEA is a mathematical liner programming method used to evaluate which DMU lies at the boundary of performance. DEA provides an overview of the efficiency of multiple inputs and outputs, tests each DMU and compares its performance with the best performing unit. The best-performing unit should lie at the border of performance. If the unit is not on the performance limit, it is known to be inefficient.

Cooper et al. (2000) and Coelli et al. (1998) argued that DEA had gained prominence due to its well-known benefit. First, it has the ability to manage multiple inputs and multiple outputs simultaneously due to the use of linear programming. Linear programming can accommodate a large number of variable inputs and outputs. Second, DEA has no previous assumptions regarding assigning weights to the various inputs and outputs. The weights are explicitly derived from arbitrary subjective weighting. DEA delivers a set of weights that

maximise the performance of the unit, subject to the non-border boundary weights to be violated by other units. Third, the measurement units of the various inputs and output variables do not need to be consistent. The analysis used DEA under the assumption of a variable return to scale. Second, the technological and cost efficiencies are calculated using equations 1 and 2 as set out below.

$$TE = \min_{z,\theta} \theta$$
$$subject - to$$
$$z.Y \geq y_0$$
$$z.x \leq \theta.x$$
$$z_i \geq 0$$
$$\sum_{i=1}^{n} z_i = 1 \text{.....(1)}$$

$$CE = \min_{z,\lambda} \lambda$$
$$subject - to$$
$$z.Y \geq y_0$$
$$z.C \leq \lambda.C_0$$
$$z_i \geq 0$$
$$\sum_{i=1}^{n} z_i = 1 \text{.....(2)}$$

Now it is simple to calculate the allocative efficiency by AE = CE/TE.

The question of the possible impacts on the performance of the contextual variables outside company control is required in a two stage cost-efficiency analysis. The Tobit model is used due to the lower tail censoring of the distribution created by the DEA. Thus, the use of OLS estimates is not an efficient method of assessing the desired efficacy variables in the hospital, because the dependent variable is limited to 0-1. Green (1994) proposed zero censorship for computational purposes and converted DEA efficiency scores to zero left-censored inefficiency scores using the equation as follows:

Cost Inefficiency = (1/ DEA CE score)-1

The linear regression model is as under:

$$y_i^* = \beta + x_i + u_i, u_i \square N(0.\sigma^2)$$
$$y_i = y_i^* if y_i^* > 0:$$
$$y_i = 0 if y_i^* \leq 0 \text{.....(3)}$$

For i = 1, ... ,n, is the vector of unknown parameters. xiis the vector of explanatory variables. The observed data y*i ,represent possibly censored versions of yi, where “ineff” is the inefficiency score and xi are the contextual factors.

Variables and Data

In this analysis, we used the value added of 86 pharmaceutical companies as a measure of production and three input variables with their corresponding input prices (Table 1). Total number of workers, raw materials and wages used input variables. While the explanatory variables are the market shares of companies, the Herfindahl-Hirschman Index (HHI) of the company's market concentration, asset prices and energy.

Table 1: Input, Outputs and Explanatory Variables

Output	Value Added of the firms
Inputs	Total Number of Staff
	Raw Material of firms
	Salaries of the Staff
Explanatory Factors	Firm’s Market Shares calculated aseach Pharmaceutical firms’ value added divided by all Pharmaceutical firms’ value added
	Herfindahl-Hirschman Index (HHI) is the market concentration measure obtained by summing the squares of market shares of each Pharmaceutical firms which is 0.898 calculated as $HHI = \Sigma_n S_i^2$ Si: market share of firm i
	Values of Assets
	Energy Consumption

Results

First, the efficiencies scores are calculated by using DEP 2.1 software. After that the cost inefficiency scores are regressed some explanatory factors which are not under the control of the firms. Results are given as under.

Descriptive Statistics

Summary statistics of the inputs, outputs and explanatory variables is given in Table 2. There is higher level of variation in the value added as shown maximum and minimum values of statistics. Similar situation is also found for other all inputs and explanatory factors as shown in Table 2.

Table 2: Summary Statistics of Inputs, Outputs and Explanatory Variables

	Value Added	Raw Material	Employs	Salaries	Market Share	Assets	Energy
Mean	85253	113419	114	25621	0.012	65724	5231
Median	11306	30118	43	5340	0.002	13836	1388
S.D.	222412	315964	192	59069	0.030	192280	10396
Max	1419177	2609389	950	430837	0.194	1654832	72655
Min	-5667	140	3	66	-0.001	175	35

Authors' Calculation

Level of Cost Efficiency in the Pharmaceutical Firms of Punjab

The average value of cost efficiency (CE-277) indicates that there is 72 percent cost increasing inputs in the pharmaceuticals firms of Punjab. It is determined by the 61 percent misallocation and 46 percent wastage of the resources in the firms. Only two firms Medipharm(pvt.) Ltd and Japan herbal pharma (pvt.) Ltd are operating at cost frontier with score CE-100 using as reference for others firms. If remaining firms reduce 74 percent of their inputs, their current output level will remain same. In these two firms, allocation of resources is also 100 percent (AE-1.00). As for as utilization of resources is concerned, out of 86 firms 13 firms Ccl pharmaceuticals (pvt.) Ltd., Medipharm (pvt.) Ltd., Shaigan

pharmaceuticals (pvt.) Ltd., Javedunani laboratories, Maqbooldawakhana& herbal pharma (pvt.) Ltd., Japan herbal pharma (pvt.) Ltd., Elite pharma (pvt.) Ltd., Rehmanunanidawakhana, p-369, street no. 11, afghan abad, faisalabad., Hermain herbal pharma, New altafdawakhana, New farandawakhanamianwali, Riazdawakhana, and Standard dawakhana are utilizing the resources 100 percent efficiently (TE-1.00). However, level of inefficient utilization of resources is higher as compare to misallocation due to which the level of cost is higher in these films and individuals are facing higher prices of drugs.

Table 3: Cost Efficiency of the Pharmaceutical Firms of Punjab

Firms	Technical Efficiency	Allocative Efficiency	Cost Efficiency
Cotton craft (pvt.) Ltd.	0.101	0.874	0.088
Dosaco laboratories	0.298	0.567	0.169
English pharmaceutical industries	0.354	0.414	0.146
Ethical laboratories (pvt.) Ltd.	0.292	0.848	0.248
Flow pharmaceuticals (pvt.) Ltd.	0.476	0.991	0.472
Highnoon laboratories ltd.	0.187	0.953	0.179
Himont pharmaceuticals (pvt.) Ltd.	0.170	0.939	0.160
Jawa pharmaceuticals (pvt.) Ltd.	0.083	0.375	0.031
Marhaba laboratories	0.094	0.301	0.028
Orta laboratories (pvt.) Ltd.	0.562	0.827	0.465
Pdh pharmaceuticals (pvt.) Ltd.	0.461	0.859	0.396
Pharmedic laboratories (pvt.) Ltd.	0.308	0.579	0.179
Qintar pharmaceuticals 14a psiesargodha	0.151	0.246	0.037
Rehman rainbow (pvt.) Ltd.	0.532	0.723	0.385
Rekopharmacal (pvt.) Ltd.	0.822	0.649	0.534
Renaconpharma (pvt.) Ltd.	0.404	0.838	0.339
Sapient pharma	0.326	0.593	0.193
Siza international (pvt.) Ltd.	0.518	0.674	0.349
Vega pharmaceuticals (pvt.) Ltd.,	0.830	0.972	0.807
Wilshire laboratries (pvt.) Ltd.	0.601	0.245	0.147
Ccl pharmaceuticals (pvt.) Ltd.	1.000	0.814	0.814
Ashraf laboratories(pvt.) Ltd.	0.297	0.813	0.241
Crescent cotton industries (pvt.) Ltd.	0.574	0.989	0.568

Dawakhana hakim ajmal khan (pvt.), ltd.,	0.422	0.540	0.228
Elixir laboratories (pvt.) Ltd.	0.334	0.515	0.172
Irfan pharmacy (pvt.) Ltd.	0.212	0.379	0.080
Medipharm (pvt.) Ltd.	1.000	1.000	1.000
Micko industrial chemicals (pvt.) Ltd.	0.369	0.703	0.259
Pharmawise labs (pvt.) Ltd.	0.992	0.439	0.436
Sharex laboratories (pvt.) Ltd.	0.064	0.792	0.050
Synchro pharmaceuticals (pvt.) Ltd.	0.562	0.434	0.244
Unexo labs (pvt) ltd	0.099	0.777	0.077
Ideal pharmaceutical industries	0.215	0.762	0.164
Popular chemical works pvt ltd	0.253	0.858	0.217
Hamaz pharmaceutical (pvt.) Ltd.	0.169	0.887	0.150
Shaigan pharmaceuticals (pvt.) Ltd.	1.000	0.540	0.540
Lahore chemicals and pharmaceutical works (pvt.) Ltd.	0.357	0.847	0.303
Home opathic stores and hospital	0.453	0.644	0.292
Hansel pharmaceutical (pvt.) Ltd.	0.550	0.759	0.417
Venus pharma	0.348	0.319	0.111
Medivet (pvt.) Ltd.	0.640	0.418	0.268
Pharmagen ltd.	0.295	0.037	0.011
Saffron pharmaceutical (pvt.) Ltd.	0.821	0.489	0.401
Schazoozaka (pvt.) Ltd.	0.129	0.975	0.125
Zakfas pharmaceutical (pvt.) Ltd.	0.094	0.184	0.017
Munawarpharma (pvt.) Ltd. - ii	0.121	0.949	0.115
Novamed pharmaceuticals	0.258	0.946	0.244
Batala pharmaceuticals	0.300	0.119	0.036
Goodman laboratories	0.404	0.787	0.318
Prime laboratories (pvt) ltd	0.251	0.860	0.216
Hafiz pharama industry	0.250	0.406	0.102
Al-haram dawakhana	0.396	0.509	0.202
Pdhlaborateries (pvt) ltd	0.403	0.921	0.371
Rax	0.607	0.387	0.235
Bara dawakhana	0.427	0.551	0.235
Honig pharmaceutical laboratories	0.337	0.857	0.289
Javedunani laboratories	1.000	0.331	0.331
Mumtazdawakhana	0.559	0.710	0.397
New pak herbal pharma	0.500	0.450	0.225

Unimark pharmaceutical	0.336	0.481	0.161
Cheema laboratories (unani) (pvt.) Ltd.	0.431	0.674	0.290
Bio labs (pvt) ltd.	0.063	0.512	0.032
Helicon pharmacuitekpakistan (pvt.) Ltd.	0.169	0.322	0.054
Maqbooldawakhana& herbal pharma (pvt.) Ltd.	1.000	0.337	0.337
Hi-warble pharmaceutical (pvt.) Ltd.	0.043	0.248	0.011
Ameer pharma (pvt.) Ltd.	0.167	0.842	0.141
Al-noormedica (pvt.) Ltd.	0.464	0.735	0.341
Grand pharma (pvt.) Ltd.	0.160	0.707	0.113
Ayko industries (pvt.) Ltd.	0.688	0.890	0.612
Japan herbal pharma (pvt.) Ltd.	1.000	1.000	1.000
Elite pharma (pvt.) Ltd.	1.000	0.634	0.634
Prix pharmaceutica (pvt.) Ltd.	0.084	0.448	0.038
Well & well pharma (pvt.) Ltd.	0.105	0.161	0.017
Olive laboratories	0.157	0.825	0.129
Rehmanunanidawakhana, p-369, street no. 11, afghan abad, faisalabad.	1.000	0.457	0.457
Kakasianpharmaceutecalspvt, limited	0.258	0.375	0.097
Bmapharma	0.417	0.188	0.078
Ambardawakhana (regd.)	0.601	0.456	0.274
Balalunanilabutries	0.742	0.797	0.591
Barkatunanidawakhana	0.600	0.411	0.247
Feroz din ajmalidawakhana	0.482	0.682	0.329
Hermain herbal pharma	1.000	0.333	0.333
New altafdawakhana	1.000	0.318	0.318
New farandawakhanamianwali	1.000	0.859	0.859
Riazdawakhana.	1.000	0.125	0.125
Standard dawakhana	1.000	0.337	0.337
	Descriptive Statistics		
Mean	0.460	0.608	0.277
Median	0.404	0.639	0.238
Standard deviationf	0.302	0.257	0.218
Maximum	1.000	1.000	1.000
Minimum	0.043	0.037	0.011

Authors' Calculation

Determinants of Cost Inefficiency

In this section, the study presents the empirical result of Tobit model which shows the effect of market share, market concentration, energy and assets on the cost inefficiency of the pharmaceutical firms in Punjab. There is positive effect of HHI and energy on the cost efficiency of the Pharmaceutical firms. While market share and value of assets have negative effect on cost efficiency. The Table 4 indicates that while holding all explanatory variables constant, the pharmaceutical firm's cost inefficiency is 0.4793. The result also shows thatmarket share is positively related to the cost inefficiency of pharmaceutical firms in Punjab. This is owing to the fact that a 1 percent increase inmarket share will increase the industry's cost inefficiencyby about 32 percent. While, a 1 unit increase in market concentration will decrease the cost efficiency by percent4.7292 units. From the result, all the explanatory variables are statistically significant. Market concentration has higher significant on the cost efficiency of the firms. Increase in the value of assets will also increase the cost inefficiency by 91 percent in the firms. The increase in the use of energy will make the pharmaceutical firms more cost efficient.

Table 4: Tobit model

	Coefficient	Standard Error	t-Stat	P-Value
C	0.47931	0.0028374	17.83583	5.27381E-17
Market Share	0.3204	0.0073927	1.849424	0.000248721
HHI	-4.7292	0.0000268	5.385329	0.000062415
Value of Asset	0.9183	0.0067231	1.362940	0.003354102
Energy	-0.00638	0.0283945	1.732064	0.002937124

Author's Calculation

Conclusion

Cost efficient pharmaceutical firms are very useful for the society. Because these have both internal externalities and external externalities. Internally, most economical firm will be

the most profitable for the administrators while externally most economical firms will provide least price output for the consumer. In case of pharmaceutical firms of Punjab, it is observed that more than 95 percent firms are cost inefficient. The level of cost increasing inputs is also high. The main reason behind is that there is higher level of wastage and misallocation of resources in these firms. It indicates the higher level of disguised unemployment in these firms which is the burden on the firms. This in turn produce the negative effect on public in term of high drug prices. These firms should reduce their inputs to reduce its cost at give output level. Government should also remove the monopoly of pharmaceutical companies so that people can get drugs at cheaper price. Because higher market concentration (HHI) shows the higher positive effect on cost efficiency in second stage analysis.

References:

Abrol, D., Prajapati, P., & Singh, N. (2017). Globalization of the Indian pharmaceutical industry: implications for innovation. *Institutions and Economies*, 327-365.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European journal of operational research*, *2*(6), 429-444.

Coelli, T. (1998). A multi-stage methodology for the solution of orientated DEA models. *Operations Research Letters*, *23*(3-5), 143-149.

Cooper, W. W., Seiford, L. M., & Zhu, J. (2000). A unified additive model approach for evaluating inefficiency and congestion with associated measures in DEA. *Socio-Economic Planning Sciences*, *34*(1), 1-25.

Danzon, P. M., Nicholson, S., & Pereira, N. S. (2005). Productivity in pharmaceutical–biotechnology R&D: the role of experience and alliances. *Journal of health economics*, *24*(2), 317-339.

De Carolis, D. M. (2003). Competencies and imitability in the pharmaceutical industry: An analysis of their relationship with firm performance. *Journal of management*, *29*(1), 27-50.

El-Mashaleh, M. S., Rababeh, S. M., &Hyari, K. H. (2010). Utilizing data envelopment analysis to benchmark safety performance of construction contractors. *International Journal of Project Management*, *28*(1), 61-67.

Färe, R., Grosskopf, S., &Roos, P. (1995). Productivity and quality changes in Swedish pharmacies. *International Journal of Production Economics*, *39*(1-2), 137-144.

Farrell, M. J., &PEARsoN, E. S. (1957). SERIES A (GENERAL). *Journal of the Royal Statistical Society. Series A (General)*, *120*(3), 253-29.

González, E., &Gascón, F. (2004). Sources of productivity growth in the Spanish pharmaceutical industry (1994–2000). *Research Policy*, *33*(5), 735-745.

Greene, W. H. (1994). Accounting for excess zeros and sample selection in Poisson and negative binomial regression models.

Hashimoto, A., &Haneda, S. (2008). Measuring the change in R&D efficiency of the Japanese pharmaceutical industry. *Research policy*, *37*(10), 1829-1836.

Mazumdar, M., & Rajeev, M. (2009). *A comparative analysis of efficiency and productivity of the Indian pharmaceutical firms: a malmquist-meta-frontier approach*. Institute for Social and Economic Change.

Saranga, H., &Phani, B. V. (2004). The Indian Pharmaceutical Industry–An Overview on Cost Efficiency using DEA. *Unpublished Working Paper*.