

Original Article

Evaluation of productivity in Iranian pharmaceutical companies: A DEA-based Malmquist approach and panel data analysis

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ABSTRACT

Objective: In this study, we aimed to assess comparative productivity of 21 pharmaceutical companies in Iran during 2000–2013.

Methods: To evaluate the productivity trend of pharmaceutical companies in Iran, we used data envelopment analysis-based Malmquist index. “Total assets” and “capital stock” as inputs and “net sales” and “net profit” as outputs extracted from Tehran stock exchange, were selected to be included in the analysis. This method provides the possibility for analyzing the performance of each company in term of productivity changes over time. We also used an estimation generalized least square panel data model to identify the factors that might affect productivity of pharmaceutical companies in Iran using EVIEWS 7 and Deep 2.1 software.

Findings: The mean total productivity during all years of the study was 0.9829, which indicates the improvement in their overall productivity. The results, over the 13-year period, indicated that the range of productivity changes in pharmaceutical companies, that were included in this study, was between 0.884 and 1.098. Panel data model indicated that age of company could positively ($t = 4.765978, P < 0.001$) and being located in cities other than Tehran (the capital) could negatively ($t = -5.369549, P < 0.001$) affect the productivity of pharmaceutical companies. The analysis showed the new policy (brand-generic scheme) and also the type of ownership did not have a significant effect on the productivity of pharmaceutical companies.

Conclusion: In this study, pharmaceutical productivity trends were fluctuated that could be due to the sub-optimal attention of policy makers and managers of pharmaceutical companies toward long-term strategic planning, focusing on productivity improvement.

Keywords: Data envelopment analysis; Iran; panel data model; pharmaceutical; productivity

INTRODUCTION

To ensure population's access to medicines, one of the important goals of Iranian Ministry of Health (MOH) has been to produce pharmaceuticals and vaccines locally.^[1] To support domestic

manufacturers, government has set high-level tariffs and also limitations on medicines import. This has raised some concerns about the abilities of domestic manufacturers, facing real competitive situation with the presence of international companies after joining the World Trade Organization.^[2] The cost-plus pricing model by MOH, in which the price of medicines is calculated by adding a predefined margin for manufacturers, distributors, and pharmacies to total cost of production, has also led companies to invest more on marketing and sale activities rather than research and development;^[3] it could probably undermine their productivity. Evaluation of efficiency and productivity of pharmaceutical companies could

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provide valuable information for policy-makers about their former policies and guide them for further decisions in term of short and long-term effects on the domestic production body. The asset productivity of pharmaceutical companies in Iran has not been evaluated before, however, some studies have been published on different productivity-related topics in Iran: One study on the impact of intellectual capital efficiency on market value,^[4] one study about the efficiency of regulatory departments in pharmaceutical companies,^[5] an efficiency trend analysis of pharmaceutical companies before and after implementation of brand-generic scheme,^[6] one study on labor productivity in pharmaceutical industry,^[7] and a study on productivity indices in pharmaceutical industry^[8] that none of these studies are direct evaluation of productivity in pharmaceutical manufacturers. Also in none of these published studies, the influencing factors on productivity of pharmaceutical companies have been evaluated.

In this study we aimed (1) to assess comparative productivity of Iranian pharmaceutical companies during a 13-year period of time and (2) to identify probable factors affecting pharmaceutical companies' productivity.

METHODS

To evaluate the productivity trend in Iranian pharmaceutical companies, we used data envelopment analysis (DEA)-based Malmquist index. This method makes it possible to analyze the performance of each company in term of productivity changes over time. DEA is a nonparametric method based on linear programming which was developed in order to calculate the relative technical efficiency among organizations or firms that are called decision-making units (DMUs).^[9] In DEA, for multiple input and output data, an efficiency frontier would be constructed, and then the efficiency of investigated DMUs would be calculated based on their position relative to this frontier, respectively.^[10] This relative efficiency would be calculated in three main categories: Relative technical efficiency, relative pure (managerial efficiency), and relative scale efficiency. Malmquist productivity index (MPI) is a common index to compare total productivity changes over time. For the 1st time, Caves *et al.*^[11] used MPI for productivity measurement. Total productivity change could be decomposed to three main components.

We can calculate MPI through the following equation:

MPI = Technical efficiency change × technological changes.

Technical efficiency change could be decomposed to include two separate components: Pure efficiency

change and scale efficiency change; therefore we can write:

$M = (\text{pure efficiency change} \times \text{scale efficiency change}) \times \text{technological change.}^{[12-14]}$

This decomposition could help a company to realize the reason of productivity change in a particular time period.

According to input-oriented DEA approach, the MPI >1 indicates performance improvement of a company via minimization of inputs, and the index upper than 1 shows the worsening performance of a company.^[15]

Input and output

To select variables as inputs and outputs for measuring DEA-based MPI change, an expert panel was held with the presence of experts in the pharmaceutical industry including three financial managers and three manager directors. They evaluated all variables which were accessible from financial statements of Iranian pharmaceutical companies. Finally, "total assets" and "capital stock" as inputs and "net sales" and "net profit" as outputs were selected to be included in the analysis. The companies' data were extracted from the "balance sheet," "profit and loss statement," and other financial statements available in Tehran stock exchange (TSE) database^[16] for the fiscal years March 19, 2000–March 19, 2013.

Inclusion/exclusion criteria

There are 89 pharmaceutical production companies in Iran.^[17] Because of the homogeneity assumption of DMUs in DEA, only the finished product manufacturers were included in the analysis. To assure the access to reliable data, another inclusion criterion for selecting companies for the study was being listed in TSE. Considering the time period of the study, (2000–2013) the companies whose data were available for this period of time and also matched our stated inclusion criteria were included in analysis (totally 21 companies).

Analysis

Malmquist index

Using Deep 2.1, a computer program which is designed to conduct DEA, we analyzed total factor productivity change and its components including technological change, technical efficiency change, and scale efficiency change for each company during 2000–2013.

Identifying factors affecting productivity

We also used an estimation generalized least square (EGLS) panel data model to identify the factors that might affect productivity of pharmaceutical companies in Iran. The independent

variables used in the model included “age of company,” “location” (whether it is located in capital or not), “generic-brand policy” (the effect of this policy on productivity), and “type of ownership” (public or private).

RESULTS

With reference to the above-mentioned points, as shown in Table 1, the results of our study over the 13-year period indicated that the range of productivity changes in pharmaceutical companies that were included in this study was between 0.884 and 1.098. The best and the worst companies in term of performance were B and J, respectively. The results also shown that seven companies had improved in term of pure efficiency (management efficiency) and nine companies had improved in term of technical efficiency over the years of study. Among these pharmaceutical companies, seven companies did not improve with regard to total factor productivity [Table 1].

According to our analysis [Table 2], the mean total productivity during all the years of study was 0.9829; this showed that overall, there was an improvement in productivity in the years of study. There was a fluctuation in the trend of productivity over all the studied years [Figure 1] so that although productivity worsened in 2000, 2003, 2005–2007, 2009, and 2012, as observed, the productivity had improved in

other years that might indicate the inconsistency of companies’ policies regarding productivity.

The second section of our study [see Table 3] showed that productivity of pharmaceutical companies in Iran might be correlated with the age and location. The EGLS panel data model indicated that the age of company could positively ($t = 4.765978$, $P < 0.001$) and being located in the cities other than Tehran (the capital) could negatively ($t = -5.369549$, $P < 0.001$) affect the productivity of pharmaceutical companies. Figure 2, which is about the trend of mean productivity index, shows that the Malmquist

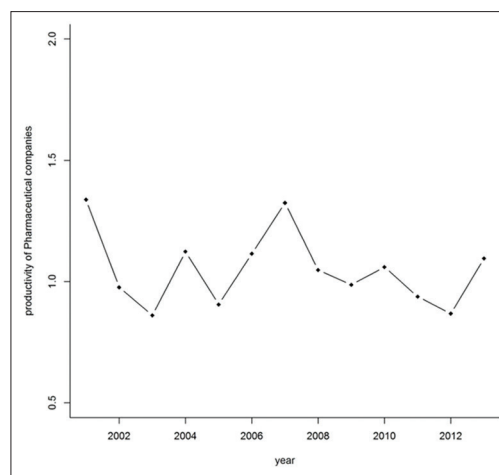


Figure 1: Trend of mean Malmquist index in studied companies during 2000–2013

Table 1: Average productivity index of Iranian pharmaceutical companies during 2000-2013

Company name	Technical efficiency change	Technological change	Pure efficiency change	Scale efficiency change	Productivity changes (Malmquist index)
A	1.032	0.958	0.998	1.034	0.989
B	1	0.884	1	1	0.884
C	0.922	1.008	0.997	0.925	0.930
D	0.976	1.041	0.974	1.002	1.016
E	0.975	0.955	1	0.975	0.931
F	0.983	0.962	1.011	0.972	0.946
G	1.003	0.964	0.991	1.012	0.966
H	1.036	1.011	1.039	0.997	1.046
I	0.967	0.922	0.972	0.995	0.892
J	1.072	1.026	1.022	1.047	1.098
K	0.975	0.973	0.997	0.978	0.949
L	0.968	1.007	1.004	0.963	0.975
M	1.074	0.942	1.075	0.999	1.011
N	0.99	0.999	0.978	1.012	0.989
O	1.001	0.992	1	1.001	0.993
P	1.037	0.977	1.021	1.015	1.013
Q	1.009	0.979	1.009	1	0.987
R	1.014	0.972	1.017	0.997	0.986
S	1.076	0.974	1.108	0.971	1.047
T	1.036	1.008	1.003	1.033	1.045
U	0.998	0.96	1.02	0.978	0.957
Geometric mean	1.006	0.976	1.010	0.995	0.982

Table 2: The mean of productivity changes in pharmaceutical companies calculated via MPI during 2000-2013

Year	Technical efficiency change	Technological change	Pure efficiency change	Scale efficiency change	Productivity changes (Malmquist index)
2000					
2001	0.582	2.059	0.788	0.738	1.198
2002	1.780	0.505	1.270	1.402	0.899
2003	1.012	0.781	1.093	0.926	0.790
2004	1.008	1.057	0.994	1.015	1.066
2005	0.988	0.845	1.04	0.949	0.835
2006	1.198	0.851	1.055	1.135	1.02
2007	0.968	1.295	0.97	0.998	1.254
2008	1.099	0.943	1.091	1.007	1.037
2009	0.858	1.125	0.913	0.94	0.965
2010	1.165	0.896	1.05	1.109	1.043
2011	0.988	0.929	0.995	0.993	0.918
2012	0.996	0.807	1.069	0.931	0.803
2013	0.835	1.284	0.893	0.936	1.073
Geometric mean	1.006	0.976	1.010	0.996	0.982

MPI=Malmquist productivity index

Table 3: Identification of variables affecting productivity of investigated pharmaceutical companies

Variables	Coefficient	SE	t-statistic	P
C	0.581112	0.116070	5.006570	0.0000
DPOL	-0.010938	0.020865	-0.524213	0.6006
LIFE	0.006748	0.001416	4.765978	0.0000
OWNER	-0.014791	0.014300	-1.034286	0.3020
CAP	-0.096060	0.017890	-5.369549	0.0000
REVOLUTION	0.210412	0.030335	6.936388	0.0000
@TREND	0.002883	0.003175	0.907952	0.3648
Weighted statistics				
R ²	0.229827	Mean dependent variable	1.290306	
Adjusted R ²	0.205970	SD dependent variable	0.594109	
SE of regression	0.351716	Sum squared residual	30.18374	
F-statistic	1.250261	Durbin-Watson stat	2.194402	
P(F-statistic)	0.002813			
Unweighted statistics				
F ²	0.211037	Mean dependent var	1.025474	
Sum squared residual	30.75000	Durbin-Watson stat	2.165122	

C=intercept, DPOL=implementation of the new policy (brand-generic scheme), LIFE=age of company, OWNER=type of ownership; CAP=being located in the capital, REVOLUTION=being established before or after 1979. SE=Standard error, SD=Standard deviation

index is higher in companies located in Tehran, the capital of Iran. This analysis indicated no significant relationship between the implementation of the new policy (brand-generic scheme) and the type of ownership with the productivity of pharmaceutical companies.

Only less than 50% of companies experienced improvement in managerial and technical efficiency.

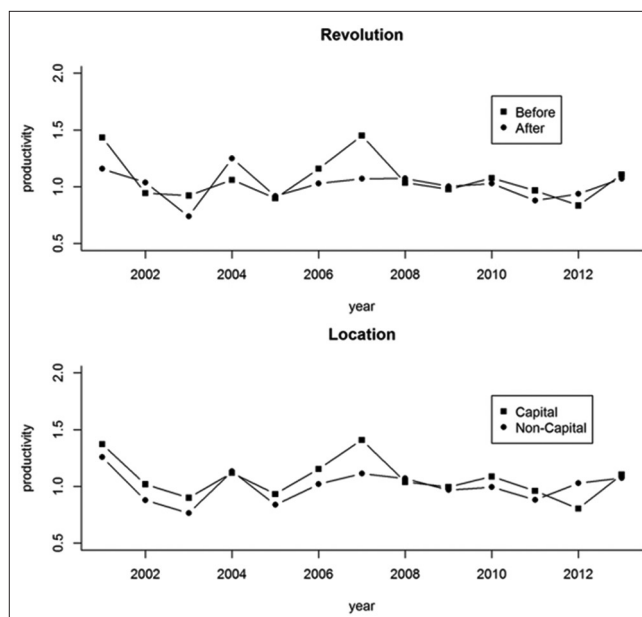


Figure 2: Trend of productivity during 2000–2013 considering the location and revolution

Moreover, of all investigated variables, age of company, being located in the capital, and being established before 1979 revolution showed significant relationships with productivity index of Iranian pharmaceutical companies. We also used this panel data model separately for the data collected before and after 2004, when the brand-generic scheme policy was introduced. This sub-analysis also did not change the former results.

DISCUSSION

Regarding the findings, 15 out of 21 investigated companies had averagely improved in term of

productivity in the years of study. It means that these companies had been able to improve their performance averagely via minimizing inputs during the period of study. This study also showed that there was no correlation between productivity and the net profit of companies: Two most profitable companies were at the end of productivity score rank.

In this study, technical efficiency change and pure efficiency change negatively affected the productivity; however, the technological change and scale efficiency change had a positive effect. The result of this study also indicated that during the period of investigation, total productivity of pharmaceutical companies had a fluctuating pattern. This could be due to frequent policy changes and instability in industrial and macroeconomic environment. As another reason, companies were not following a well-designed and long-term strategy focusing on productivity improvement.

Econometric models including panel data model were used to evaluate and report the effects of different variables on efficiency or productivity score.^[18] The results of our panel data model present multiple likely reasons for higher level of productivity in pharmaceutical companies located in Tehran (the capital city) compared with those in other cities. These factors can lead to either lower production cost or more commercial opportunities. As a reason, higher level of technology and research funds may be obtainable in capital. It is also worth-mentioning that companies in Tehran may access distribution networks better. It is mainly because of concentration of distribution companies in Tehran as the capital of the country, in which a significant proportion of private and public pharmacies, hospitals, and other dispensers of pharmaceuticals exist. Another probable reason could be related to the access to experts and human sources with a higher level of education. Because of higher standards of living in the capital, these experts prefer to live in Tehran and companies in other cities are faced with human resource problems. The companies in capital have the potential to lobby to influence the MOH and Food and Drug Organization.^[19-21]

Because almost all companies established before 1979 revolution were international companies with higher technology status compared with companies established after the revolution, the observed correlation between the establishment date of companies and productivity might be justified.

This study is the first assessment of productivity in Iranian pharmaceutical industry in which Malmquist index and panel data model were applied, and its results could be used by industrial policy-makers

and managers of the pharmaceutical industry. This method had been previously used to analyze the productivity of pharmaceutical companies in India^[22] and Spain^[23] In Iran, a similar analysis has been conducted in other industries and fields such as cement,^[24] health care sector, and hospitals.^[25]

In this study, technical efficiency change and pure efficiency change negatively affected the productivity; however, the technological change and scale efficiency change had a positive effect. This analysis indicated that the managerial index in the proper utilization of resources in pharmaceutical companies seems to be undesirable. To overcome this issue, some measures are suggested, such as: Continuous assessment of performance by managers and board of directors, using internal capacities for reconstruction of processes, more investment on facilities and equipment, using economies of scale, and designing incentives aligned with productivity improvement objectives.

Considering the results of our study, productivity trend in the pharmaceutical companies in this study showed a fluctuating pattern that could be probably due to the sub-optimal attention of policy-makers and managers of pharmaceutical companies toward long-term strategic planning and focusing on productivity improvement. It seems to be effective and useful to apply strategies and techniques for productivity improvement in pharmaceutical companies including appropriate management, using internal capacities for reconstruction of processes, more investment on facilities and equipment, using economies of scale, and providing an ideal workplace for productivity improvement.

This study had some limitations such as its limited number of investigated pharmaceutical companies. There are 89 pharmaceutical manufacturers in Iran^[17] from which we only studied 21 companies because of limitations in accessing reliable financial data for them. Hence, there might be a challenge in generalizing the results to all other companies working in the pharmaceutical industry in Iran. In this method, the results are strongly dependent on the selection of inputs and outputs for measuring productivity. It is suggested to conduct further similar studies using other inputs and outputs for the pharmaceutical companies studied in this paper, and to compare the results with each other. The other probable limitation may be about the quality of input data. In this analysis, we only included the companies listed in TSE, because their data were likely more reliable; however, it is likely that for-profit companies report false financial data.

In this analysis, we studied only a 13-year time period because of lack of available data for included

companies, however analyzing longer periods could provide more reliable results.

AUTHORS' CONTRIBUTION

MV: Study design and manuscript writing and data collection, AHM: Study design and manuscript writing, FF: Supervision on all study process, checking the manuscript, MY: Study design analysis, SY: Data collection, MA: Study design analysis, VV: Study design analysis, ERD: Study design analysis, AK: Study idea and supervision on all study process.

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