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THE ESTIMATION OF PHARMACEUTICAL PRODUCTION FUNCTION IN IRAN

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Abstract: *This study was an attempt to address the function of pharmaceutical production and its features in Iran especially in terms of scale economies. It also studied the status of using the production inputs of pharmaceutical companies in Iran in terms of efficiency. To examine these, the production function was estimated in the country's pharmaceutical industry with the new economic theories using the statistical data of pharmaceutical manufacturers. The main elements of production and the effect of using each one in pharmaceutical production were determined. To estimate the model, a non-homogeneous production function was used which was a particular type of quadratic logarithm and the Cobb-Douglas generalized model. This model consisted of the natural logarithm of pharmaceutical production as an endogenous variable and the natural logarithm of two independent variables as function inputs. Further, the data of 21 manufacturing plants were collected from the Food and Drug Administration. The results of the estimation revealed that the pharmaceutical production function in the pharmaceutical manufacturing companies in Iran have an increasing returns to scale. It might also be stated that the marginal production of labor (MP_L), the elasticity of labor (E_L), the marginal production of production lines (MP_P) deployment, and the elasticity of production to the number of production lines (E_P) is negative.*

Keywords: *Pharmaceutical industry, non-homogeneous production function, manufacturing plant, returns to scale, marginal production of labor (MPL), marginal production of production lines (MPP).*

INTRODUCTION

The core objective of the presentstudy was to estimate the production function of pharmaceutical companies in Iran. Therefore, the data provided by the Food and Drug

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Administration on the production amount of Iran's pharmaceutical companies and the production factors involved in this production were used. Using the estimated production function, the relationship between different factors of production and the pharmaceuticalproduction amount were interpreted. Moreover, the effect of each inputon the production, the sensitivity of production to any of the factors of production and returns to scale of production was also examined.

PHARMACEUTICAL INDUSTRIES IN IRAN

The pharmaceutical industry plays a major role in modern societies as not only its results have a tangible impact on gross domestic product (GDP), but also it has a role in the public health system with its main output (pharma). The industry has been one of the key factors in increasing the human lifespan during the last century and has caused rich and poor countries to enjoyaccessing to public health and its improvement and development.

However, comparing the Pharmaceutical industry of Iranwith the pharmaceutical industry in the world shows that the pharmaceutical industry in Iran has no significant role in the global scale. The pharmaceutical industry on an international level is that due to the high cost of research and development, the discovery and production of new pharmaceuticals can only be performed by a few companies which exclusively keep oneconomic activities to compensate for their costs. The pharmaceutical companies defend their high prices by referring to their acceptance of risk in the process of discovering and developing new product and spending high costs for the introducinga new product to market, so that the least amount of money that has been reported to develop a new product was about 500 million dollars.

To compensate for the high costs, the innovator of a new pharmacy keeps the relevant technology confidential and then sells it after supplying his/her costs. On the other hand, after the disclosure of technology at the internationallevel, the buyer companies produce the pharma with a few steps lower than the original quality. The existing technologies in the pharmaceutical industry of Iran are given to the pharmacists with a difference of twenty to thirty years through the third and fourth hand channels. Unfortunately, due to economy and alsopharmaceutical production in pharmaceutical companies, no competitive pharma is produced in terms of quality in the global market.

Among the economic industries of Iran, the pharmaceutical industry is an important industry. Currently, over 79 manufacturing units operating in the pharmaceutical production sector are registered and about 40 companies are active in the production of pharmaraw materials. Investment in the pharmaceutical industry of Iran can be divided into two distinct periods. The first period was the pre-revolutionary period in 1357 which was mainly formed with foreign investments by Western companies. In that period, about 85% of pharmas were imported from abroad and 80% were produced under license from foreign companies and their

formulations. However, some domestic manufacturing units were activein that period. The second period is related to the post-revolutionary period of 1977 which was mainly formed with the withdrawal of foreign companies and was managed by the government or public institutions. Gradually, the private sector became active in this field. The worst situation in the pharmaceutical industry is related to the structure of the product which needs import despite the relative development of technical knowledge and technology andthe supply of food and pharmaceutical raw materials. Due to the fact that the production of pharmaceutical products can only be seen as a step toward self-sufficiency when it is along with the production of pharmaceutical raw materials in the country, finding a solutionin this sector seems to be necessary. This research examined the status of production in pharmaceutical manufacturing plants in Iran.

LITERATURE OF THE PHARMACEUTICAL INDUSTRY

A. Internal Studies

Ebadi Fard and colleagues in a study titled "Estimating the demand for medicine in the Islamic Republic of Iran" estimated the demand for medicine for urban and rural households in Iran and identified related effective variables. In this study, the data related to the household budget were used but due to the lack of family physicians and recording the medications prescribed by doctors in Iran, the demand for medicine in Iran cannot be estimated precisely and the presented analysis are not representatives of the actual demand in the society.

Using tools and techniques of economic analysis in the evaluation of medicine and other health interventions is not new. In Iran, since the seventies, the policy makers of the health sector trained experts in the field of economic and management issues in the health sector according to the need and necessity of equipping the above science. But unfortunately the pharmaceutical industry has been neglected and ignored despite the massive investments in tourism and financial costs.

Mazhabian from the Pharmaceutical Industry Associationin his study titled "The threats and opportunities in the pharmaceutical industry" examined the general problems facing the pharmaceutical industry and discussed the threats of the industry in detail. He also mentioned some issues such as specific issues in the pharmaceutical industry including dependence on imported raw materials, patent medicine by large multinational corporations, the high costs of research and development, the tendency of physicians and popular culture to the use of foreign medicine and resistance to medicine prices and concluded that if the pharmaceutical industry is not supported, the industry will suffer from the loss of direct investment costs, the increase of unemployment in the country and the loss of foreign exchange reserves.

Rahimi in 2009 in her thesis titled "The effects of trade on the pharmaceutical industry in Iran in the case of accession to the World Trade Organization (WTO) examined the effect of Iran's membership in the WTO on exports, imports, quality and survival of the pharmaceutical industry. The result uncovered that the membership in the WTO has a positive effect on the export of the country's pharmaceutical industry, while it is also influential on the imports in the country's pharmaceutical industry and does not jeopardize the survival of the country's pharmaceutical.

Sharifi and PiraliHamadani in separate studies in 2005, Sanayi in 2009, and Hamtaraz and Hozuri in 1388 have raised the issue of medicine quality. The pharmaceutical industry in the world requires the establishment of quality assurance system in the design, manufacture and control of medicine products because of the importance of this activity and its products.

PiraliHamadani in 2003 discussed the issue of investment in the pharmaceutical industry in the world and predicted that the volume of the pharmaceutical market in the world will exceed $ 500 billion annually.

Haji Miri in 2007 examined the medicine smuggling and counterfeit medicine. Medicine smuggling gives the smugglers the largestbenefit after drug and weapon smuggling, so that nowadays 90% of the medicine in the third world countries and between 4 and 25% of the medicine in developed countries comes through smuggling. The arrival of smuggled and counterfeit medicine to the pharmaceutical market is a global and inclusive problem that may include a large part of the country's pharmaceutical market.

Ekhterayi in a study titled "The challenges faced with the Pharmacoeconomics in Iran" in 1384 examined the export promotion and import substitution strategies in the pharmaceutical industry and concluded that the substitution of imports of final medicine has an annual savings of $ 3.2 billion in foreign exchange. The low price of the pharmaceutical supply caused the inadequate income from the basic production and adjustment in research and development costs, construction and marketing of the industry that will, in turn, result to the decreased rate of growth and development in the pharmaceutical industry. Meanwhile, the investment in the production of pharmaceutical raw materials and final herbal medicine with the export development strategy is sound and the chance of exporting the final medicine is very low and inaccessible. In addition, the Western companies are also lurking the adjustment of national self-sufficiency in the hope of reducing government support from public manufacturers with Patent laws (intellectual rights) and the political differences between Iran and America have decreased the chance of their presence. Finally, he emphasized that considering the strategic planning in the pharmaceutical industry by the government can create a powerful base for the country's self-sufficiency, entrepreneurship and the development of non-oil exports for this knowledge-based industry.

Najafi (2005) in his study titled "Towards a strategic partnership with pharmaceutical laboratories in the worldwide" concludes that one of the problems of pharmaceutical industry is the vulnerability and the lack of enough industry power which is the result of many small and weak factories. One of the best solutions in this regard is merging the factories or at least holding the large pharmaceutical companies in the country.

In another report entitled "A short review of the medicine status in the country" by Mohsen Pour and Akhavan Behbahani conducted in the Office of Social Studies of Health Commission of the House in 1384, the medicine status before and after the revolution, the quality of Iranian medicines, the price of medicines, and single-prescription centers were studied. In the studiedyears, the number of manufactured medicines produced in Iran was significant and the value of imported medicines was more. On average, during 1999 to 2002, the total value of imported medicines to total medicines was about 18% that calls into question the claim of pharmaceutical industry's self-sufficiency.

B. External Studies

According to the World Health Organization in 2013, the global pharmaceutical market is $ 300 billion in a year's turnover and an increase of $ 400 billion in the next three years is also predicted. Ten large pharmaceutical companies control a third of this market. Several companies have more than ten billion dollars sale and a profit margin of around 30%. Six companies are American and four other companies are European. It is anticipated that the companies in North and South America, Europe and Japan will be developed to the extent to be able to conquer 85% of the global pharmaceutical market by the end of the twenty-first century. These companies spend a third of the total sale revenue on marketing the products that is almost double the revenue spent on the research and development.

According to the last report in 2012, two-thirds of transactions in the pharmaceutical industry takes place in America and Western Europe.It is noteworthy that, on average, the profit margins for pharmaceutical companies in America in April 2013 were 5.4% and the biggest profit margin as 18.4% was owned by Pfizer group.

The global pharmaceutical market during the years 2003 to 2012

	2003	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Global Market (Billion dollars)	5022	564/5	611	657/8	729.3	801/4	834/4	891/3	964/3	962/1
Growth (percent)	–	7/8	704	701	7	6/4	7/1	5/5	5/3	2/4

Source: IMS Health Intelligence Applied, 2013

Fremantle and Hill maintain that the pharmaceutical industry is the second largest industry in the world in terms of market value. The world's twenty best-selling pharmaceutical companies show that the economic benefits of production are several

times the bank interest rates. In addition, a percentage was added to the profits and economic benefits of manufacturers in order to develop and promote the research and discovery of new medicines and also update the medical information, to inform society and create the markets and identity for medicine manufacturers in the world.

Smith reported in 1993 that the price elasticity of demand for medicine was estimated as –0.1 and Peter reported in 2008 that the price elasticity of demand for medicine for the elderly and high-income Australian people was estimated as –0.1.

RESEARCH METHOD

This study focused on the discovery and interpretation of the relationship between the relevant variables. It was an applied research and its results could be used to improve the conditions of the production plans. The population of this study consisted of 21 manufacturing plants of Iran which included different product lines during the years 1986 to 2013 from the Food and Pharma Administration.

The data of the variables discussed in this study were cross-sectional data at the end of each fiscal year of the manufacturing plants. Using these data and econometric methods for panel data and using the new econometric methods and Statasoftware for data analysis, the relationshipbetweenpharma production and labor and production lines as the representatives of investment in pharmaceutical manufacturing plant were analyzed in the form ofpharmaceutical production function.

To estimate the relevant regression, the studybyRamcharran's(2011) entitled as "The pharmaceutical industry of Puerto Rico: Ramifications of global competition" was used in whichthe pharmaceutical production was estimated as:

$$Q = e^{a_0} P^{a_1 + a_3 \ln L} L^{a_2}$$

Where Q, total value added to GDP by the pharmaceutical industry; P, the number of plants; L, the number of workers.

Since Eq.(1) is multiplicative, it can be written in double logarithmic for matas:

$$\ln Q = a_0 + a_1 \ln P + a_2 \ln L + a_3 (\ln P \times \ln L)$$

This regressionwas necessary to carry out the Fisher and Hausman tests to study the panel, pooled, random or fixed data.

First Test

Testing the hypothesis of the plant effects homogeneity versus plant effects heterogeneity in production degree in the years 2013-1986 (Fisher's test).

The calculated value of the sample function F was equal to 41.45, thus the null hypothesis is rejected with certainty. Therefore, it might beconcluded that existing data do not provide the Pooled possibility and the Panel data must be used.

Now the question may be raised whether $\mu i(s)$(plants) are random or fixed.

Second Test

Testing the hypothesis of random effects versus fixed effects (Hausman test).

Since the values of the calculated sample function Wald is equal to 45.03 and is larger than the Chi-square quantile, thus the null hypothesis of true random effects exponentiallyis rejected. Thus, the fixed effects exponentiallymust be used.

The results of tests show thatthe intended model in this study is the fixed effects model (cross-sectional or cyclical)which represents a condition in which the intercepts or special effects have a fixed structure. In this model the number of coefficients is in such a way which is estimated without difficulty.

Since in the present model, Q represents the total amount of production and P and L (the number of production lines and the number of labor) represent the variables affecting the products of n-the plantin period t, based on the fixed effects model the two manufacturing plantsthat have the factors affecting the same production should certainly have the same level of production. If there are no differences in their production, it could be due to the non-observable effects described by the fixed values of theintended model. These factors can be institutional factors which affect the entire production, but it is usually difficult to measure them. Also other factors such as the predictions made of the international economy which isalmost identical between the manufacturing plants but change over time can be altered in this model.

In fact, in this model each section is considered with all its special features by entering the fixed effects in the specified model, thus the effect of non-observable factors related to the sections on the behavior of the dependent variable can be studied.

The results of the model estimate are as follows:

$$\begin{array}{lcccc} \text{Ln } Q = 9.926564 + 5.104863 \text{ Ln } P + 2.403509 + \text{Ln } L - 0.9694429 (\text{Ln } P \times \text{Ln } L) \\ \qquad\quad (7.37) \qquad (4.28) \qquad (8.65) \qquad (-4.10) \\ \rho = \quad 0.000 \qquad 0.000 \qquad 0.000 \qquad 0.000 \end{array}$$

$F(19.154) = 459.11$, Prob (F-statistic) = 0.000

Variables Used in the Model Include

Q : the amount of production

Ln P : the number of production lines used in plants as capital

Ln L : the number of labor

It should be noted that the values in the parentheses of computational t values and in the next row the numbers in front ofñ indicate the confidence levels.

Given the estimated coefficients at the above function and with the assumption of other fixed conditions,1 percent of increase in production lines causes5/104 increase

in the rate of production. Also, 1 percent of increase in the number of labor causes 2/ 403 increase in the rate of production.

Efficiency of Production Factors

The marginal productivity labor (MPL) is positive and increasing at the beginning of the period but faced with a sharp decline after 1981 and then remained at a constant level. During the next years this indicator became negative and its negative value greatly increased so that in the years 2012 until 2013, the marginal productivity labor increased in this industry. If the data of Hakim pharmaceutical factory are not included in the calculations, the marginal productivity labor will show negative values from the beginning. Another measure of the marginal productivity labor isOutput Elasticity of Labor (EL) which indicates a similar pattern and reached from 1.33 in 1986 to - 1.9 in 2013. This index was positive during the years 1365 to 1381 and then negative after those years. In general, the calculation of the Output Elasticity of Labor has declined which indicates a decreasing curve.

The results suggest that the pharmaceutical industry of Iran does not use the labor efficiently. Efficiency of a production factor includes not only the technical relationship between input and output, but also a clear idea about the –minimizing the management behavior cost especially in science-based industries requires skilled labor.

The marginal productivity of production lines (MPP) also indicates a different situation. Over the years 1986 to 1990 this indicator has had a positive and increasing trend. But then, in the years 1991 to 1996 it showed negative values that decrease each year so that its value became positive in the next four years. But from 2002 onward, the marginal productivity ofproduction lines became negative and the situation got worse every year so that it slightly improved in the years 2012 until 2013 although it still shows a negative efficiency.

There was a similar pattern for another factor which was the Output Elasticity of production lines which showed positive values at the beginning and then the negative values after the half of the period. The index has also declined which indicates a decreasing curve. This evidence testifies to the magnitude and excess capacity of the industry and the need for policies to restore the efficiency of production lines.

RTS in the pharmaceutical industry of Iran has steadily declined during in the period of calculation. The efficiency of this period is determined with the feature of scale declining efficiency (or increasing the long-term average total cost) during this period. The calculated RTS fully reflects the increasing returns to scale in the industry.

CONCLUSION

In this study, the pharmaceuticalproduction function was estimated in line with the new economic theories. Using the statistical data of pharmaceutical companies and

the main production inputs, the effect of using each one on the pharmaceutical production was determined. To estimate the model, a nonhomogeneous production function was employed which was a particular type of quadratic logarithm and the Cobb-Douglas generalized model. This model comprised the natural logarithm of pharmaceutical production as an endogenous variable and the natural logarithm of two independent variables as function inputs. For this purpose, the data of 21 manufacturing plants including various product lines over the years 1986 to 2013 were gathered from the Food and Drug Administration. The findings of the estimation showed that the pharmaceutical production function in the pharmaceutical manufacturing companies in Iran have an increasing returns to scale.

To put it another way, the pharmaceutical industry of Iran is inefficient in using the production inputs. It can also be stated that the marginal productivity of labor (MPL), the elasticity of labor (EL), the marginal production of production lines deployment and the elasticity of production to the number of production lines (EP) is negative. Thus, the pharmaceutical industry of Iran does not use the production factors of labor and production lines efficiently.

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