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An Analysis of Effective Factors on the Technical Efficiency of Health Production in the OIC Countries

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Abstract
The importance of community's health followed by the consideration of endogenous growth models has led to an increase in health expenditure of countries to speed up economic growth and development. This has made the efficiency of health production function to an essential issue especially in developing countries. Based upon this, the present study with employing the stochastic frontier analysis method looks for identifying the main determinants such as economic(children immunization and age dependency ratio), environmental (the rule of law) and social(globalization) conditions on technical inefficiency of health production function between member countries of Organization of the Islamic Conference (OIC) in the period of 1998-2007. The empirical results show increasing the efficiency of health production through improvement in economic and environmental condition. But the increase in socialization globalization such as social factor has led to a decrease in technical efficiency that may be due to the lack of appropriate culture of using new technologies and modern social relations affected by the process of globalization in such countries.

Keywords: Health production function, Inefficiency effects, Panel Data, Technical efficiency

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1. Introduction

After the endogenous growth models were introduced in the 1960s, the subject of community's health was taken into consideration as an effective factor on the formation of human capital and subsequently on the economic growth and development. Therefore, like education, health was considered as a capability which makes the life of human being more valuable. Today, health along with education is accommodated as the main element of economic wealth and as a capital commodity. Health has had a wide impact on the community's economy and can be constituted from different aspects, including investment on health that can directly influence the efficiency of labor force.

Narayan et al. (2010) suggest that it raises the physical capacities of the labor force, like strength and tolerance beside its mental capacities, including learning ability through experience or the reasoning ability of the labor force.

Also, Weil (2007) states that improvement of the community's health status increase the motivation for gaining knowledge. Investment in knowledge acquisition can also lead to a longer work life with a greater performance.

Thus, the healthy workers not only increase effective labor supply by less work absenteeism due to their health condition, but also can consume more calories as a result of health expenditures reduction due to the less use of health services. And subsequently, they provide higher performance capability and even more creation and innovation.

In recent decades, the health expenditures in most of the countries and particularly in developing countries have significantly increased, in order to accelerate the economic growth of society and the acquirement of higher welfare. In the meantime, determining the effective factors such as economic, social, and environmental conditions on increasing the life expectancy as the community's health output, followed by identifying the effective factors on technical efficiency of this production process, can be very useful for the policymakers of this type of countries.

An extensive body of literature has addressed the empirical measurement of efficiency in health care institution around the world.[2] And while hospitals have been the subject of most of these efficiency studies to date, the efficiency of other health care institution has also been addressed. These include physician practices, nursing homes, health maintenance organizations, and substance abuse treatment organizations. In these studies, a few articles considered the efficiency of health care in terms of health production function. These kinds of articles either in terms of one output or multiple output models, in both DEA and SFA methods, used disability adjusted life expectancy (DALE) variable as the health output.

On the other hand, health economists have been interested in the impact of marginal contribution of selected environmental, socioeconomics, behavioral, and medical inputs on various measures of health outcomes. To investigate these relationships, empirical studies have adopted a health production function analytical framework, where health is viewed as an output that is produced by a set of inputs. For this purpose, some studies like Auster et al. (1969), Grossman (1972), Silver (1972), Hadley (1982), Muller (2001), Thornton (2002) and Fayissa and Gutema (2005) have attempted to estimate an aggregate, multifactor health production function.[3] The major advantage of estimating an aggregate health production function is that estimates of the overall effect of medical care utilization on the health status of the population can be obtained (Thornton, 2002).

However, up to now, the health efficiency and the factors which are effective on it have not been examined by this type of production function (Kumbahakar, 2010)[4].

Based upon this, the present study attempts to identify the effective factors such as economic, social, and environmental on the technical inefficiency of health production function by employing the method of Battese and Coelli

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[2] Brief description of them can be found in Worthington (2004).

[3] It is important to note that a relatively large number of studies have examined the impact of medical care and other factors on health outcomes using the individual as the unit of analysis (see, for example, Newhouse and Friedlander (1980); Rosen and Taubman (1982); Taubman and Rosen (1982); Leigh (1983); Berger and Leigh (1989); Kenkel (1991).

[4] He used different health production function and different effective factors on health efficiency for World Health Organization (WHO) member countries.

(1995) based on production function introduced by Fayissa and Gutema (2005) The general advantage of determining effective factors on the technical efficiency by an aggregate production function and the estimation of the effect of each factor on the technical efficiency, is in such a way that it can help policymakers and statesmen in designating and orientating macro policies along with the economic growth and increasing society's welfare, beside optimizing the health expenditures.

The rest of the paper is organized as follows. Section 2 includes an empirical framework derived from the proposed theoretical model by Fayissa and Gutema (2005) and the stochastic frontier analysis method by Battese and Coelli (1995). Data presentation covers Section 3. Section 4 is devoted to the analysis report of the estimated results, and Section 5 encompasses the discussion and conclusion.

2. The Empirical Framework

Fayissa and Gutema (2005) presented an empirical health production function in a linear logarithmic form of the Cobb-Douglas production function through generalization of health production function developed by Grossman (1972) based on micro-economic data for macro-economic data, which can be specified as:

$$h_{it} = \Omega + y'_{it}\alpha + s'_{it}\beta + v'_{it}\varphi + e_{it} \quad (1)$$

where the subscripts i and t represent country and time, respectively, h is natural logarithm of average health status of country i, Ω is an estimate of the initial health stock of the region, y is natural logarithm vector of economic factors, s is natural logarithm vector of social factors, v is natural logarithm vector of environmental factors, e is compound error term, The α, β, γ are vectors of unknown economic, social and environmental factors parameters to be estimated, respectively.

According to stochastic frontier analysis approach introduced by Battese and Coelli (1995), the compound error term of the production function can be separated into two parts as the follow

$$e_{it} = \varepsilon_{it} - u_{it} \quad (2)$$

where $\varepsilon_{it}{}'s$ are random variables which are assumed to be independently and identically distributed $N(0,\sigma_\varepsilon^2)$, and independent of the $u_{it}{}'s$; and $u_{it}{}'s$ are non-negative random variables, referring the technical inefficiency in production, and are assumed to be independently distributed as truncations of the $N(z_{it}\delta,\sigma_u^2)$ distribution. Following Battese and Coelli (1995) $\mathrm{u}_{it}{}'\mathrm{s}$ can be represented as:

$$u_{it} = z_{it}\delta + w_{it} \quad (3)$$

where z_{it} is the vector of explanatory variables influential on the technical inefficiency of the health production function over time, and δ is the vector of unknown parameters to be estimated and $w_{it}{}'s$ are the random variables defined by the truncation of the normal distribution with zero mean and variance, σ_u^2, such that the point of truncation is $-z_{it}\delta$, i.e., $w_{it} \geq -z_{it}\delta$. These assumptions are consistent with u_{it} being a non-negative truncation of the $N(z_{it}\delta,\sigma_u^2)$ distribution (Battese and Coelli, 1995).

Maximum likelihood techniques are used to simultaneously estimate the parameter of the stochastic production frontier model in Equation (1) and those of the technical inefficiency model in Equation (3).

It should be noted that the technical inefficiency model in Eq. (3) can only be estimated if the technical inefficiency effects, u_{it}'s, are stochastic and have a particular distributional specification (Coelli and Battese, 1996). Hence, there is growing interest to test the null hypotheses that the inefficiency effects are not present, $\gamma = \delta_0 = \delta_1 = .. = \delta_3 = 0$; the inefficiency effects are not stochastic, $\gamma = 0$; and the coefficients of the variables in the model for the inefficiency effects are zero, $\delta_1 = .. = \delta_3 = 0$. These and related null hypotheses are tested through imposing restriction on the model and using the generalized likelihood-ratio statistic, λ, to determine the significance each of the restrictions. The generalized likelihood ratio statistic is given by:

$$\lambda = -2\{ln[L(H_0)] - ln[L(H_1)]\} \quad (4)$$

where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null (H_0) and alternative (H_1) hypotheses, respectively. If the given null hypothesis is true, λ has approximately χ^2- distribution or mixed χ^2- distribution when the null hypothesis involves $\gamma = 0$ (Coelli, 1995).

Given the model specification, the technical efficiency of the health production function of each country for each year, defined as the ratio of observed output to the corresponding frontier output, is given by:

$$TE_{it} = exp(-u_{it}) \quad (5)$$

The prediction of technical efficiencies is based on the conditional expectation of expression in Eq. (4), given the values of $\varepsilon_{it} - u_{it}$ evaluated at the maximum likelihood estimates of the parameters of the stochastic frontier model (Battese and Coelli, 1988). The frontier production for each country can be computed as the actual production divided by the values of technical efficiency estimate.

3. Data and Variable Measurement

The required data for this study were collected from 43 countries of 57 countries of Organization of the Islamic Conference (OIC) in the period of 1998 to 2007, which related information was taken from World Bank (2010) in the format of World Development Index and World Government Index. Furthermore, the information about globalization index (weighted average of indicators of economic, social and political globalization) was also taken from KOF Index of Globalization.

The selection of variables in an empirical analysis should be based on availability and reliability of the data. According to Behrman and Deolalikar (1988) life expectancy, particularly at birth and mortality rate, particularly for infants and children would suggest as indicators of health output for aggregate studies. In this empirical analysis, we utilize life expectancy at birth as the dependent variable. It indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. The variables representing economic factors (y) are limited to GDP per capita (y_1), which is calculated in constant US dollars; the ratio of total health expenditure to GDP (y_2), as indicator of availability of the facilities per capita. For reducing the possible effects of multi-collinierty that arises from co-movement of health expenditures and income, it is used as the ratio of total health expenditure to GDP. It covers the provision of health services, family planning activities, and emergency aid designed for health; and food production index[5] (y_3) as a measure of food availability. This index requires inserting population in the function as a correction of aggregation figures to per capita levels. It covers food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because they have no nutritive value. Variables representing the social factors (s) are limited to literacy rate (s_1), which is taken as a proxy for education. It is the percentage of people above 15 years who cannot read, write and understand a simple statement on their daily activities; population (s_2) which is a demographic social factor, here it appears in the function in relation with food availability as mentioned before; and lifestyle (s_3) represented by adolescent fertility rate (births per 1000 woman ages 15-19)[6]. And ultimately, urbanization rate or the share of total population living in urban areas (v_1), and carbon dioxide emissions per capita (v_2) which those are stemming from the burning of fossil fuels and the manufacture of cement, represent the environmental factors (v).

Moreover, the vector of factors affecting the technical efficiency of health production function such as economic factors which are represented by immunization, measles (% of children ages 12-23 months) (z_1), measures the percentage of children ages 12-23 months who received vaccinations

[5] This index is related to the 1999-2001=100 base year.

[6] Since alcohol consumption in Islamic countries is not a good representative for lifestyle, this variable is a replacement of the alcohol consumption per adult in the health production function introduced by Fayissa and Gutema (2005). Furthermore, tobacco consumption wasn't reported for most of the studied countries.

before 12 months or at any time before the survey. A child is considered adequately immunized against measles after receiving one dose of vaccine; and age dependency ratio (z_2), is the ratio of dependents-people younger than 15 or older than 64 to the working-age population, those ages 15-64. And the social and environmental factors are expressed by the index of globalization (z_3) and the rule of law (z_4), respectively. Rule of law measures the extent to which agents have confidence in and abide by the rules of society, in particular the quality of contract enforcement, the police, and the courts, as well as the likelihood of crime and violence.

4. Empirical Results

This section shows the statistical results of the estimation of stochastic frontier production function defined in equation (1) associated with the estimated results of the factors affecting technical inefficiency, using data presented in the previous section.

The initial estimates indicate that the coefficient of CO_2 per capita is statistically non-significant. To decide the most appropriate model, a hypothesis test was implicated using the likelihood ratio statistic, in which the coefficient of CO_2 variable in the model is zero. The hypothesis test is presented in table 1. The likelihood ratio statistic doesn't reject the null hypothesis that $\varphi_2 = 0$ even at less than 10 percent level of significance.

Table 1: Test of Hypothesis Involving CO_2 Coefficient of the Health Production Function

Variable	Null Hypothesis	Log-likelihood test		Statistic (λ)	Decision
		Restricted Model	Unrestricted Model		
v_2	$\varphi_2 = 0$	652.94009	652.95371	0.2724	Not Rejected

Source: Authors

Thus the final estimates are obtained by elimination of this variable, i.e. CO2 per capita. The maximum-likelihood estimates for the both parameters in the health production function and technical inefficiency model for the countries involved, associated with t-statistic relating to each of these parameters are presented in table 2(These results were obtained using the computer program FRONTIER Version 4.1 (see Coelli, 1994).).

Table 2: Parameter Estimates of Stochastic Production Frontier and Technical Inefficiency Models

Stochastic Production Function				Technical Inefficiency Model			
Variable	Parameter	Coefficient	T student	Variable	Parameter	Coefficient	T student
constant	Ω	3.8055624	34.073	constant	δ_0	- 0.5261481	-5.169
y_1	α_1	0.0396629	8.972	z_1	δ_1	- 0.0012073	-2.807
y_2	α_2	0.0191447	2.579	z_2	δ_2	0.0083329	10.064
y_3	α_3	0.0199884	1.697	z_3	δ_3	0.0017023	1.801
s_1	β_1	0.0175545	1.672	z_4	δ_4	- 0.0006643	-1.780
s_2	β_2	0.0034862	1.961	Sigma-squared	σ_e^2	0.0059653	9.069
s_3	β_3	- 0.0308761	-5.740	σ_u^2 / σ_e^2	γ	0.8847365	32.793
v_1	φ_1	- 0.0295866	-2.274	Log- likelihood		652.94009	

Source: Authors

According to the results reported in Table 2, all the estimated coefficients have signs which generally conform to our expectation, and are statistically significant. Meanwhile, all the considered economic variables such as GDP per capita, the ratio of total health expenditure to GDP and food production index are estimated to be positive and acceptably have an influence on the life expectancy. This indicates that a 1% increment in GDP per capita, the ratio of total health expenditure to GDP and food production index will generate about 0.04, 0.02 and 0.02 percent enhancement in life expectancy, respectively.[7] Moreover, Table 2 reports that the coefficients of literacy rate and population have a positive impact, and the adolescent fertility rate (births per 1000 woman ages 15-19) has an indirect impact on health production,[8] suggesting that a 1% increment in the first two variables would lead to about 0.018 and 0.003 percent increment on health production function, respectively. While, a 1% increment in adolescent fertility rate will generate about 0.031 percent decrease in life expectancy at birth. Finally, a 1% increment in urbanization rate as the only environmental variable in the model produces a negative impact on health production function causes about 0.03 percent reduction in life expectancy at birth. Accordingly, health production function for all factor inputs involved is inelastic and elasticity of scale for the Cobb-Douglas production frontier which was estimated by the sum of the elasticity of the factors indicates that the health production function of involved countries experiences decreasing return to scale.

The variance parameter $\gamma = \left(\frac{\sigma_u^2}{\sigma_e^2}\right)$, which captures the total output effect of technical efficiency, is about 0.885 and significant, implies that about 88.5 percentage of estimated variance of error of the model is related to the inefficiency factor.

Generalized likelihood-ratio tests of various null hypotheses involving the restriction on the variance parameter, γ, in the stochastic production frontier and δ coefficients in the technical inefficiency model are presented in Table 3. Both null hypotheses that the technical inefficiency effects are absent and the inefficiency effects are not stochastic are rejected. Thus, the traditional estimation of average point of production function is not an appropriate estimation method used in this study.

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7 As the model is logarithmic linear, the estimated coefficients represent the amount of elasticity of the dependent variable in relation with any of the explanatory variables.

8 Fayissa and Gutema (2005) by considering the population variable as a countervailing variable of food production index impact, suppose the expected sign of this variable in the model as negative. However, according to independency of food production index from the measurement unit, such an interpretation may not seem very much appropriate. Here, we expect that the impact of population on health production is positive because we believe that life conditions and income improvement of societies has led to population increase in the long term by reducing mortality rate; and therefore, population multiplication is tied to a healthier society, thus the impact of population on production health could be positive. On the other hand, it is expected that a decline in the adolescent fertility rate is a sign of change in people's lifestyle from traditional to modern which will be accompanied by a reduction in malnutrition and more observation of hygiene and will lead to a positive effect on health production.

Table 3: Generalized-likelihood Ratio Tests of Hypotheses for Parameters of the Stochastic Production Frontier and Technical Inefficiency Models for Mentioned Countries

Null hypotheses	Log-likelihood test: Restricted Model	Log-likelihood test: Unrestricted Model	Statistic (λ)	Decision
$H_0: \gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$	552.99504	652.94009	199.8901**	Reject H_0
$H_0: \gamma = 0$	590.58206	652.94009	7.6299*	Reject H_0
$H_0: \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$	554.13657	652.94009	197.6070**	Reject H_0
$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$	554.15354	652.94009	197.5731**	Reject H_0
$H_0: \delta_1 = 0$	648.66112	652.94009	8.5579*	Reject H_0
$H_0: \delta_2 = 0$	589.74230	652.94009	126.3956**	Reject H_0
$H_0: \delta_3 = 0$	651.13806	652.94009	3.6041*	Reject H_0
$H_0: \delta_4 = 0$	651.17651	652.94009	3.5272*	Reject H_0

****, and * denotes significance at the 1%, and 10% levels, respectively.**
Source: Authors

The third null hypothesis, which specifies that the constant term and all the coefficients of explanatory variables influential on technical inefficiency are zero (that the technical inefficiency effects have a traditional half normal distribution with 0 mean), is rejected. The fourth null hypothesis that all the parameters of the technical inefficiency model except the constant term are zero (that the technical inefficiency effects have the same truncated-normal distribution with mean δ_0) is also rejected. Other related null hypotheses which present that each parameter of the technical inefficiency model are zero, are rejected as well.

The results for the technical inefficiency model are presented in Table 1. They specify that the inefficiency effects are influenced by all the four variables that were considered as the effectual factors on technical inefficiency of health production function. The results suggest that an increase in the economic variables, i.e. immunization, measles (z_1) and age dependency ration (z_2) would lead to decrease and increase in technical inefficiency of health production function, respectively. Similarly, two other variables which are social factor (Index of Globalization) and environmental factor (the rule of law) would also appear with positive and negative impacts on technical inefficiency of health production function, respectively.

The mean of the technical efficiency of the estimated health function (obtained using Equation (4) for each country (over the nine-year period), are presented in Table 4. It indicates that Syria with 99 percent and Nigeria with 72.07 percent have the maximum and the minimum value of technical efficiency of health production function, respectively.

Table4: Predicted Mean Technical Efficiencies of each Country for the Years 1998-2007

Country	Efficiency (%)	Country	Efficiency (%)
Albania	98.834	Malaysia	97.103
Algeria	96.258	Maldives	92.555
Azerbaijan	97.673	Mali	74.75
Bahrain	98.119	Mauritania	80.938
Bangladesh	95.655	Morocco	97.415
Benin	91.258	Mozambique	75.63
Brunei	98.579	Niger	76.842
Burkina Faso	79.72	Nigeria	72.07
Cameroon	78.492	Oman	97.777
Chad	77.701	Pakistan	94.717
Comoros	94.945	Senegal	83.707
Cote d'Ivoire	85.944	Sudan	85.744
Egypt	96.873	Suriname	97.385
Gabon	85.918	Syria	99.003
Gambia	86.286	Tajikistan	96.124
Guinea	84.929	Togo	92.354
Guinea Bissau	75.75	Turkey	96.782
Indonesia	98.011	Turkmenistan	92.492
Iran	97.569	Uganda	72.2
Jordan	97.421	United Arab Emirates	98.84
Kazakhstan	94.905	Uzbekistan	95.272
Kuwait	98.66	Total Average	90.214

***Source*: Authors**

On the other hand, the mean annual technical efficiency for all the countries reviewed in Table 5 implies that the technical efficiency of health production function tends to increase with an annual growth rate of about 0.1793 percent over time.

Table 5: Predicted Mean Annual Technical Efficiency for Mentioned Countries

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
89.569	89.713	89.933	90.057	90.207	90.207	90.250	90.420	90.759	91.025

***Source*: Author**

5. Conclusion

Although estimated results explain appropriate correspondence of model with present data, estimated coefficients show that life expectancy at birth, as a product of health section, is inelastic in relation with all variables considered as its production factors and therefore, none of these factors can have a considerable impact on it. Also, estimated elasticity of scale shows that health section in the studied countries has reached beyond increasing return to scale borders and is in economic production stage.

On the other hand, all variables considered as the effective factors on technical inefficiency of health production function in OIC countries are distinguished statistically effective on technical efficiency of health production function and the economic factor of age dependency ratio shows the highest impact on the technical inefficiency of health in a way that decline in this ratio represents improvement in economic conditions of living and causes an increase in health efficiency. Accordingly, the rest of results show that immunization expansion of children against diseases through increasing the body's resistance against diseases and also conduction of law through decreasing crime and social tensions could lead to an increase in the technical efficiency of health production function. However, the impact of general index of globalization result on the technical efficiency of health production function could probably be considered as one of the unanticipated results of this study. This result, which represents a decrease in technical efficiency of health production function through progress in the trend of globalization in this group of Islamic countries, may be due to lack of formation of proper culture of using new technologies and new social relations affected by the process of globalization in such countries.

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