Gender-Specific Stochastic Frontier Health Efficiency Model in Malaysia

Md. Azizul Baten[1, 2], Jastini Mohd. Jamil[1], Norhaslinda Zainal Abidin[1], Izwan Nizal Mohd Shaharanee[1], Ibnu Affan bin Jaafar[1]

[1]*Department of Decision Science, School of Quantitative Sciences, Universiti Utara Malaysia, 01600, Sintok, Kedah Darul Aman, Malaysia.*

[2]*Department of Statistics, School of Physical Sciences, Shahjalal University of Science and Technology, Sylhet, Bangladesh.*

baten_math@yahoo.com

***Abstract*—This study addresses an important issue of efficiency of national health care systems and develops an appropriate stochastic frontier gender-specific health efficiency model where the inefficiency term is modeled as a linear function of relevant explanatory variables. We used the latest data available on life expectancy as health outcomes and number of doctors, number of nurses, total health expenditure, GDP in prices as the inputs. Using the likelihood-ratio test, Translog stochastic frontier gender-specific health efficiency model is found an appropriate in Malaysia. From the result, total health expenditure is found significant and positively impact on life expectancy that indicates an increase in total health expenditures is expected to higher the overall health outcome measured by life expectancy while GDP in prices is observed unexpected to have a negative effect on life expectancy but significant. The population density in Malaysia is recorded to reduce the inefficiency on life expectancy and the total fertility rate is noticed unexpected to increase the inefficiency. The number of government hospitals, number of beds, and demographic rates like crude birth rate, crude death rate, infant mortality rate, and maternal mortality rate are found to reduce the inefficiency on life expectancy in good health in Malaysia. The average health efficiency for both male and female was 0.9321 and 0.9946, indicating that on an average, 93.2 percent for male and 99.4 percent for female of the health outcome potentials are realized by country Malaysia. Year-wise gender-specific health efficiency periodically fluctuates during the period of investigation. The study recommends that governments improve not only health care expenditure but also factors affecting health other than health care to reduce the burden on health-care facilities and reduce the burden of disease in Malaysia.**

***Index Terms*—Health Outcomes; Malaysia; Stochastic Frontier Analysis; Technical Efficiency.**

I. Introduction

The recent economic and financial crisis and their long-term consequences on public finances have reinforced the need to improve efficiency in the health care sector. Within the current decade, per capita expenditure on health care has increased significantly in most countries, but improvements in health outcomes have not necessarily followed. Measuring and comparing efficiency across countries represents a way to assess the rational distribution of human and economic resources. In a context of economic recession, where resource scarcity follows every manager, efficiency is the only way out. Health Care is no exception. Continuous budgetary cuts from central authorities led to increasing pressures in hospital managers to achieve efficient results. It is often argued that health care institutions are not expected to be efficient, as they do not adhere to neo-classical firm optimization behavior [1]. However, given the vast amount of resources that goes towards funding such institutions, there is a great and growing interest in examining health efficiency with the driving force for such concern being value for money.

Efficiency measurement represents a first step towards the evaluation of a coordinated health care system, and constitutes one of the basic means of audit for the rational distribution of human and economic resources [2]. Over the past two decades, efficiency measurement has been one of the most intensely explored areas of health services research [3]. The issue of health care efficiency is becoming increasingly relevant throughout the world. The application of efficiency concepts to health care systems is challenging, raising both theoretical and practical problems. Obviously, the lack of efficiency and effectiveness of such a major part in the development of social welfare services, not only reduces the quality of life, but also precludes recovery in other sectors, increasing social injustice and inequality, rising health care costs and at last make political problems [4].

Despite the empirical difficulties in applying efficiency concepts to health systems, there is a considerable body of evidence at both the macro and micro levels on the pervasiveness of inefficiency in the health sector. In order to assess (relative) technical efficiency in the health sector, this study mainly uses parametric frontier methods based on Stochastic Frontier Analysis (SFA) and SFA methods require assuming a particular functional form for the production function, which allows for the presence of both stochastic errors and inefficiency. The SFA is often preferred over a non-parametric approach, data envelopment analysis (DEA), which is limited in the number of allowable inputs and does not separate out “noise” from the inefficiency term [1]. SFA assumes a random disturbance term that is normally distributed and a technical inefficiency term that has a strictly non-negative distribution.

Worldwide, several studies have used parametric and nonparametric methods, such as DEAs and SFAs, to assess the technical efficiency of hospitals and health centers, as reviewed by [5]. SFA has been used for efficiency comparisons in health care [5]. SFA has appeared only once in the peer-reviewed literature to compare efficiency of health care in OECD countries; however, the comparison focused on hospitals [6]. [7], [8], [9], [10], and [11] compared the health system performance across (some) Central and Eastern Europe (CEE) and OECD countries. Multiple studies have used the Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) methods to assess the technical efficiency of hospitals in the developed [12][13][14] and developing countries [15][16]. Only few studies are conducted using the SFA regardless of the country studied [17][18]. Whilst most literature has focused on applying DEAs to public healthcare organizations, relatively few studies have attempted to compare DEAs and SFAs in Primary Health Cares. In light of being able to quantify efficiency, this study has the aim of identifying the best stochastic frontier health production model by performing efficiency estimations for a single year using variables from the Malaysian reality, allowing the identification of inefficiency sources. Furthermore, no studies have been performed on a national scale basis in the Malaysian context using SFA [19].

In the present study, we construct a stochastic frontier health production function with the inefficiency term modelled as a linear function of a set of explanatory variables. It is also an interest to investigate what factors might be responsible for health care systems inefficiency by using stochastic frontier analysis. The way it will explore a dengue transmission control model as a linear function of health performance and a set of identified factors.

II. Theoretical Framework of the Stochastic Frontier Model

In In the present study, we construct a stochastic frontier health production model with technical efficiency of a health care system by its ability to maximize the life expectancy of its population using a minimum amount of health care and non-health care inputs. The latest available data from the Ministry of Health, Malaysia is used to estimate the stochastic frontier health production equation, which enables not only to assess productive efficiency of national health care systems, but also to see what factors, might be responsible for their inefficiency. An advantage of Stochastic Frontier Analysis (SFA) is the ability to diagnose Latent heterogeneities among DMUs. This allows distinction to be made between effects caused by inefficiency and/or statistical errors. Whereas, DEA makes no distinction between effects caused by inefficiency and an outlier or measurement error and attributes all these effects to inefficiency [20][21]. Given these methodological concerns [22], the present study relies on SFA. Since deterministic models do not take into account of either the effects of random factors or of factors beyond the control of the producer. To overcome this disadvantage, this study is based on a production-based stochastic frontier model. This study uses the form of the stochastic production frontier model similar to that suggested by [23]. The model can be written as follows:

$$\mathrm{Y_{it}} = \mathrm{f}(\mathrm{X_{it}},\beta)+\varepsilon_i = \mathrm{f}(\mathrm{X_{it}},\beta)+\mathrm{V_{it}}-\mathrm{U_{it}} \quad i=1,2,..,\mathrm{N},\ \mathrm{t}=1,2,\ldots,\mathrm{T} \tag{1}$$

where, Y_{it} is the logarithm of the variable that measures health outcome in the i-th firm and *t-th* time period, X_{it} is the vector of inputs (health care resources) associated with health outcome in the i-th firm and *t-th* time period, and β is the vector of parameters to be estimated. V_{it}'s is distributed as $NID(0,\sigma_v^2)$ and an independent of U_{it}s. U_{it} is a non-negative random component associated with health production inefficiency, assumed to be independently distributed such that U_{it} is obtained by truncation (at zero) of the normal distribution with the mean $Z_{it}\delta$ and variance σ_u^2.

The health production inefficiency for in the i-th firm and *t-th* time period, can be expressed as:

$$U_{it} = Z_{it}\delta + W_{it} \tag{2}$$

where the random variable W_{it} follows $NID(0,\sigma^2)$, such that the point of truncation is $-Z_i\delta$. The parameters δ show how variables Z_{it} influence the inefficiency term. Here the health productive technical efficiency:

$$TE = \exp(-U_i) = \exp(-Z_i\delta - W_i) \tag{3}$$

The parameters of the production function (β) and those in the inefficiency component (δ) can be simultaneously estimated by maximum likelihood.

To apply model (1) into the data and to specify an appropriate functional form for the production of the hospital outputs from both the Cobb-Douglas and Translog we tested the null hypothesis using the Log likelihood-ratio test.

III. Data and Description of the Variables

This study is based on secondary data and information is collected from Ministry of Health (MOH). The secondary data may include e.g., life expectancy of both male and female (parameters related to human development indicators), health facilities (including number of doctors, number of nurses, total health expenditure, GDP in prices (income); some explanatory variables like population density, number of government hospitals, number of hospital beds, demographic rates, and literacy rate, etc.

The health outcome variable (y) used in this study is life expectancy of both male and female, which measures the equivalent number of years of life expected to be lived in full health and it is probably the best available to reflect the health status of the population in a country.

IV. Life Expectancy at Birth, in Years

The variable is computed by WHO and age disaggregation of mortality data: 0, 1-4, 5-9, 10-14, etc., 80-84, 85+. The following variables are included in the model as the inputs of the production function (x):

A. Total number of doctors per 100,000 populations

A doctor or physician is a person who has completed studies in medicine at the university level. To be legally licensed for the independent practice of medicine (comprising prevention, diagnosis, treatment and rehabilitation), (s)he must in most cases undergo additional postgraduate training in a hospital (from 6 months to 1 year or more). The number of physicians at the end of the year includes all active physicians working in health services (public or private), including health services under other ministries than the Ministry of Health.

B. Total number of nurses

Total number of nurses includes the number of registered nurses, assistant nurses and community nurses in Malaysia. Again division I mid-wives consist of trained nurses who are given midwifery training while in services. Division II mid-wives consists of midwives who are appointed to the post through the normal recruitment process and special training in midwifery in given

C. Total health expenditure

Total health expenditure is the sum of general government and of private expenditure on health. Estimates for this indicator were produced by WHO. The estimates are, to the greatest extent possible, based on the National Health Accounts classification. Level of public spending on health is as percent of total government spending. It includes spending from government budgets, external borrowing, grants and social health insurance funds. Per capita total expenditure on health expressed in purchasing power parity (ppp) international dollar.

D. GDP in prices

The distribution of GDP in current price is also likely to influence health care efficiency. It is also important to note that social differences in access to health care are likely to cause misallocation of health care resources by channeling them to those who can afford (often excessive) health care rather than to those who need it most. Therefore, a variable that measures GDP in current price, is included in the input component, and a positive sign of this variable's coefficient is expected. Real GDP per capita is measured in international dollar.

The variables included in the inefficiency component (z) are:

E. Population Density

Population density describes the people per sq. km of land area in Malaysia for 2015. It is available in http://data.worldbank.org/indicator/EN.POP.DNST?page=2;

F. Number of Government Hospitals

Number of government hospitals or special medical institutions in Malaysia includes the following states and others: Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Perak, Perlis, Pulau Pinang, Sabah, Sarawak, Selangor, Terengganu, W. P, Kuala Lumpur, W.P. Labuan and W.P. Putrajaya.

G. Number of hospital beds per 100,000 populations

The variable is a measure of hospital capacity. A hospital bed represents a regularly maintained and staffed bed for the accommodation and fulltime care of a succession of inpatients. It is situated in wards or areas of the hospital where continuous medical care for inpatients is provided.

H. Crude birth rate

It is one the main Demographic rates in Malaysia. 2015 which is available in https://www.statistics.gov.my/dosm/uploads/files/3_TimeSeries/MalaysiaTimeSeries2013/21Perangkaan_Penduduk.pdf;

I. Crude death rate

Population density describes the people per sq. km of land area in Malaysia for 2015. It is available in http://data.worldbank.org/indicator/EN.POP.DNST?page=2;

J. Total fertility rate

Total fertility rate is available in the website of Ministry of Health in Malaysia over the period of 1956 to 2012 and this study covers only from the year of 2000 to 2012;

K. Infant mortality rate per 1,000 live births

The variable represents a measure of the yearly rate of deaths in children less than one year old. The probability of a child is born in a specific year or period dying before reaching the age of one. The denominator is the number of live births in the same year. Infant mortality rate = [(Number of deaths in a year of children less than 1 year of age) / (Number of live births in the same year)] *1000.

L. Maternal mortality rate

It is one the main Demographic rates in Malaysia. 2015 which is available in https://www.statistics.gov.my/dosm/uploads/files/3_TimeSeries/MalaysiaTimeSeries2013/21Perangkaan_Penduduk.pdf;

M. Literacy rate

There is also a wide consensus in the literature on literacy rate as an explanatory variable in the health production function. Literacy rate is available in MALAYSIA ECONOMIC STATISTICS-TIME SERIES. 2015, www.statistics.gov.my/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09. Source: Ministry of Health, Malaysia, 2013; World Health Organization, 2012.

V. Likelihood Ratio Tests

The likelihood ratio test is an imperative feature and helps to determine whether Cobb-Douglas or Translog model are an appropriate or not. The likelihood ratio is measured as follows:

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

The Where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null and alternative hypothesis (note that this statistic has a mixed chi-square distribution). The null hypothesis is rejected when $\lambda_{LR} > \chi_c^2$.

The following null hypothesis will be tested:

$H_0 : \beta_{ij} = 0,$ the null hypothesis that identifies an appropriate functional form either the restrictive Cobb-Douglas or Translog production function. It specifies that the second-order coefficients of the stochastic frontier production function are simultaneously zero. This is done with the calculation of the maximum likelihood estimates for the parameters of the stochastic frontier models by using the computer program frontier version 4.1 developed by Coelli (1996).

VI. TRANSLOG STOCHASTIC FRONTIER HEALTH PRODUCTION MODEL

Followed by the original specification of (1), this model can be expressed in the following form:

$$Y_{it} = \alpha + \sum_{i=1}^{4} \beta_i X_i + \frac{1}{2} \sum_{i=1}^{4} \beta_i^2 X_i^2 + (V_{it} - U_{it}) \quad i = 1,2; \quad t = 1,2,3,...,13 \tag{5}$$

where Y_i represent the logarithm of the life expectancy with respect to the i-th gender male and female;

X_1 represents the logarithm of the number of doctors of the i-th male and female life expectancy;

X_2 represents the logarithm of the number of nurses of the i-th male and female life expectancy;

X_3 represents the logarithm of the total health expenditure of the i-th male and female life expectancy;

X_4 represents the logarithm of the GDP in current price of the i-th male and female life expectancy;

$\beta_1, \beta_2, \beta_3, \beta_4$ are unknown parameters for the stochastic frontier to be estimated.

The $V_i's$ are random variables assumed to be iid. $N(0, \sigma_v^2)$, independently distributed of the U_i. U_i**'s** are non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be iid. $|N(0, \sigma_u^2)|$.

The health production inefficiency effects model for i-th male and female life expectancy and t-th time period can be expressed as followed by (2):

$$U_{it} = Z_1\delta_1 + Z_2\delta_2 + Z_3\delta_3 + Z_4\delta_4 + Z_5\delta_5 + Z_6\delta_6 + Z_7\delta_7 + Z_8\delta_8 + Z_9\delta_9 + W_{it} \tag{6}$$

where the random variable W_{it} follows $NID(0, \sigma^2)$ such that the point of truncation is:

$$-Z_i\delta, \quad \delta = \delta_1, \delta_2, \delta_3, ..., \delta_9.$$

Z_1 represents the population density of the i-th male and female life expectancy;

Z_2 represents the number of government hospitals of the i-th male and female life expectancy;

Z_3 represents the number of beds of the i-th male and female life expectancy;

Z_4 represents the crude birth rate of the i-th male and female life expectancy;

Z_5 represents the crude death rate of the i-th male and female life expectancy;

Z_6 represents the total fertility rate of the i-th male and female life expectancy;

Z_7 represents the infant mortality rate of the i-th male and female life expectancy;

Z_8 represents the maternal mortality rate of the i-th male and female life expectancy;

Z_9 represents the literacy rate of the i-th male and female life expectancy.

VII. RESULTS AND DISCUSSION

Table 1 presents the descriptive statistics of the input and output variables.

Table 1
Variable Definition and Descriptive Statistics of Output and Input Variables

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Male Life Expectancy	13	70.00	72.30	71.3077	.61571
Female Life Expectancy	13	74.70	77.10	76.0923	.73763
Number of Doctors	13	15619.00	38718.00	24258.9231	7960.96233
Number of Nurses	13	29074.00	87318.00	54481.4615	17352.56490
Total Health Expenditure	13	11685.00	42256.00	24760.0769	10032.91165
GDP in Prices	13	352579.00	941237.00	607425.8462	2.04312E5
Population Density	13	71.00	89.00	80.2308	5.84742
Number of Govt. Hospitals	13	121.00	147.00	131.6923	9.05892
Number of Beds	13	34089.00	42707.00	36718.9231	2759.01288
Crude Birth Rate	13	17.20	23.40	19.0000	1.77998
Crude Death Rate	13	4.40	4.80	4.5538	.11983
Total Fertility Rate	13	2.10	3.00	2.4077	.26287
Infant Mortality Rate	13	5.70	6.90	6.4154	.29957
Maternal Mortality Rate	13	.30	.40	.3077	.02774
Literacy Rate	13	90.00	94.10	92.0077	1.27440

A. Estimation of Translog Stochastic Frontier Health Production Model

Table 2 shows the maximum likelihood (ML) estimates of parameters of the Translog stochastic frontier health production model and those for the technical inefficiency model. The estimation procedure came out with some extremely interesting findings. First, the effect of GDP in prices on life expectancy (health production) is negative and significant. The effect of total health expenditure on life expectancy is positive and significant. The coefficients of Total health expenditure has a positive impact on health production, suggesting that a 1 per cent increment in the Total health expenditure lead to 2.25 per cent increment in life expectancy. This results stands in favor to the theory and existing literature. It means that an increase in total health expenditures is expected to higher the overall health outcome measured by life expectancy. In our opinion this is very important finding as we can expect health care spending as a source of efficiency of the health care system. Therefore, this finding provides with an idea that it is important how much country can spend on health care and what does matter is how the money is spend. Another important result is associated with the spread of GDP in prices in the health care sector. We found that the use of GDP in prices is unexpected to have a negative effect on life expectancy but significant.

Table 2
Variable Definition and Descriptive Statistics of Output and Input Variables

Variables	Parameters	Estimate	Std. Error	Z value	Pr(>|z|)
Intercept	β_0	7.26E+00	9.54E-01	7.6079	2.786e-14 ***
X_1	β_1	-1.23E+00	8.57E-01	-1.4336	0.151688
X_2	β_2	-1.97E-01	7.86E-01	-0.2503	0.80234
X_3	β_3	2.25E+00	6.20E-01	3.6342	0.0002789 ***
X_4	β_4	-1.11E+00	4.70E-01	-2.3705	0.0177651 **
X_1^2	β_1^2	1.30E-01	8.91E-02	1.4541	0.145929
X_2^2	β_2^2	1.90E-02	7.58E-02	0.2501	0.802472
X_3^2	β_3^2	-2.36E-01	5.97E-02	-3.9462	7.939e-05 ***
X_4^2	β_4^2	9.01E-02	4.08E-02	2.2099	0.0271137 **
Estimation of Inefficiency Effects Model					
Intercept	δ_0	-3.11E-01	8.99E-01	-0.3464	0.729047
Z_1	δ_1	4.78E-02	2.16E-02	2.2076	0.0272707 **
Z_2	δ_2	-1.79E-02	1.07E-02	-1.6787	0.0932125*
Z_3	δ_3	-3.40E-07	2.06E-05	-0.0165	0.986838
Z_4	δ_4	-2.67E-03	4.45E-02	-0.0601	0.952061
Z_5	δ_5	-2.09E-01	1.19E-01	-1.7627	0.0779494*
Z_6	δ_6	4.80E-01	3.45E-01	1.3922	0.163872
Z_7	δ_7	-1.52E-01	1.20E-01	-1.2638	0.206292
Z_8	δ_8	-2.25E+00	2.12E+00	-1.0627	0.287928
Z_9	δ_9	4.18E-03	1.41E-02	0.2962	0.767108
Variance Parameters					
Sigma-squared	σ^2	2.42E-03	1.42E-03	1.7062	0.0879789*
Gamma	γ	1.00E+00	1.37E-03	729.0508	< 2.2e-16 ***

*** indicates 1% level of significance, ** indicates 5% level of significance, * indicates 10% level of significance.

The coefficient of GDP in prices has a negative impact on health production, suggesting that a 1 per cent increment in the GDP in prices generate 1.11 per cent reduction in life expectancy. However, the effect of the GDP in prices on health condition is negative; this situation can be explained by the fact that the implementation of new healing requires substantial financial earnings mainly in terms of GDP. Furthermore, the population density, total fertility rate and literacy rate have positive but statistically insignificant impact on health condition measured by life expectancy. It is an interesting finding is that the total fertility rate is unexpected to increase the inefficiency of the health care system. The same is true for the literacy rate but its impact remains statistically insignificant. Finally, the number of govt. hospitals, number of beds, crude birth rate, crude death rate, infant mortality rate, and maternal mortality rate in Malaysia are expected to reduce the inefficiency on life expectancy in good health. The analysis of the “inefficiency component” tells that Malaysia having more equally distributed number of government hospitals come out with a negative sign is expected to provide its states with a better health condition.

The lower part of Table 2 presents the variance parameters, the amount of the sigma-squared, and gamma parameter. The inefficiency variance (σ^2) was estimated 0.0024 but statistically insignificant and (γ) with a standard error of 0.00137, which was highly significant. The parameter (γ) associated with the variances in the stochastic translog production frontier is estimated to be one, according to:

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} \quad (0 \le \gamma \le 1), \quad \sigma_u^2$$

plays a dominant role, while the effect of σ_v^2 almost ignored. So we draw a conclusion that the mode is reasonable in design and reflects the technical inefficiency very well.

Table 3 illustrates the technical efficiency of health affiliated to both male and female life expectancy. The average efficiency of the health for both male and female was 0.9321 and 0.9946, which indicated 7% and 1% potential for improvement respectively. The efficiency of the male health ranged from 92.5% to 93.9% without considering the severity of illness. Over the period of the study, the efficiency increased from 92.5% in 2005 to 93.1% in 2006 and increased again from 92.8% in 2011 to 93.6% in 2012. There was no full-efficient healthcare system (equal to 1) during the entire study period for both male and female life expectancy. The male health efficiency showed a steady increase from 2005 until 2012 with some fluctuations. The efficiency of the female health ranged from 98.7% to 99.8% without considering the severity of illness. Over the period of the study, the efficiency increased from 98.7% in 2005 to 99.8% in 2010 and decreased 99.4% in 2011. The female health efficiency showed a steady increase from 2000 until 2004, then again started to increase with some fluctuations from 2005 to until 2010. On the other hand, the year-wise Gender-specific health technical efficiency for Translog model reviewed in Table 3 implies that technical efficiency periodically fluctuates during the period of investigation. The average efficiency is estimated 0.932 and 0.994 indicating that, on an average, only about 93.2 percent and 99.4 of the health outcome potentials are realized by country Malaysia. Figure 1 shows the increasing trend as a whole for the both male and female health efficiency.

Table 3
Year-wise Gender-Specific Health Technical Efficiency in case of Translog Model

Year	Male Health Efficiency	Female Health Efficiency
2000	0.934857	0.997623
2001	0.939003	0.998851
2002	0.934396	0.993783
2003	0.935341	0.997342
2004	0.934632	0.997727
2005	0.925607	0.987829
2006	0.931214	0.993726
2007	0.929193	0.991569
2008	0.927231	0.989388
2009	0.928669	0.99222
2010	0.932412	0.998731
2011	0.928368	0.994124
2012	0.936942	0.997846
Mean	0.932143	0.994674

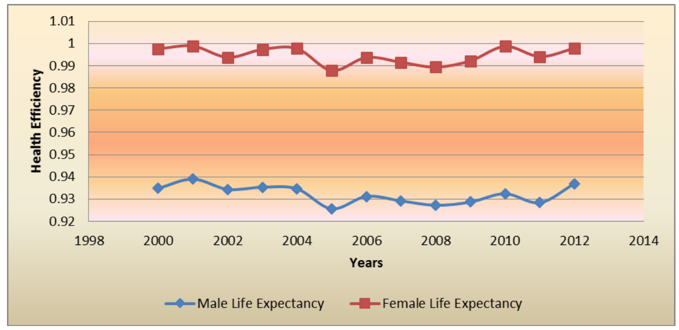

Figure 1: Gender-specific Health Efficiency with Translog Model over Time

B. Results of Likelihood-Ratio Test

The results of the hypothesis test for health production efficiency model is presented in Table 4. The null hypothesis is $H_0 : \beta_{ij} = 0$, which specifies that Cobb-Douglas stochastic frontier health production model is more preferable than Translog stochastic frontier health production model or not. From the result it is observed that the form of Translog production model (LR=56.485) was more appropriate as the stochastic frontier model of the health production under investigation in comparison to Cobb-Douglas form (LR= 50.734). Based on LR test Translog stochastic frontier production model is found an appropriate. Regarding the population and the statistical method of the present study, a fitted SFA model was applied and the results of the study were assessed and analyzed by Frontier 4.1 (Tim Coelli, 1996) software.

Table 4
Selection of Appropriate Model for the Estimation of Efficiency using Likelihood Ratio Test

	Degrees of freedom	Log-Likelihood	Degrees of freedom	Chi square	Pr(>Chisq)
Cobb-Douglas Model	17	50.734			
Translog Model	21	56.485	4	11.501	0.02147 **

*** indicates 1% level of significance
** indicates 5% level of significance
* indicates 10% level of significance

VIII. Conclusion

The efficiency of health care system is an extremely complex issue and its redesigning is not an easy task. The main difficulty of assessing the health system's performance lies within the choice of the right outcome measures. The most often these measures are the health status variables, such as different indicators of life expectancy. In this study we have also applied this measure – the healthy life expectancy. This study has constructed a stochastic frontier gender-specific health production model for panel data during 2000 to 2012 where considered life expectancy of both male and female as the output and number of doctors, number of nurses, total health expenditure and GDP in prices as the inputs. The study has estimated a stochastic production frontier in order to assess the level and determinants of technical efficiency for health production in Malaysia. The health production data and other relevant information are analyzed by estimating the

Translog stochastic production frontier involving a model for technical inefficiency effects. Translog frontier health production model was found to be more preferable than Cobb-Douglas using Likelihood-Ratio test. Modeling the inefficiency term as a linear function of a set of explanatory variables has enabled us to identify factors responsible for inefficiency.

The estimated positive effect of total health expenditure are found to be 2.25 for Translog frontier health life expectancy efficiency model, and it can be viewed is an important determinant of a country's health life expectancy. This study confirms that the efficiently performing health care system cannot only be achieved by increasing health care spending. The negative effect on health life expectancy, GDP in prices is very small and statistically significant. The results show that inefficiency of national health care systems is inversely related with GDP in prices and directly related with total health expenditure. It is most relevant to health policies is that health care is more efficient in country with public expenses in total health expenditure, which means health care systems that rely more on total health expenditure.

Year-wise gender-specific health efficiency shows overall the increasing trend as a whole with some fluctuations for the Translog frontier health production model. No full-efficient score (equal to 1) during the entire study period is observed for gender-specific health production model.

However, since this result has not been confirmed by other studies, further research is needed to substantiate it both theoretically and empirically. Quantifying the efficiency of national health care systems and identifying factors that cause inefficiency helps to see the potential for improvements and design policies aimed at raising health care efficiency. Overall, the results of this study suggest that policy and healthcare decision makers should exercise its stewardship function to develop, implement, and enforce policies which aim at improving health system performance, promoting the health of the people and managing of resources in health sector. Thus the government proactive approaches should be given to activities that go beyond the health system to influence the main determinants of health factors in improving life expectancy and aid populations to access available resources.

ACKNOWLEDGMENT

The authors wish to acknowledge the financial support provided by the FUNDAMENTAL RESEARCH GRANT SCHEME (FRGS), (Grant number: 12898), Universiti Utara Malaysia, Sintok, Kedah, Malaysia, for conducting this research.

REFERENCES

[1] Rowena, Jacobs. 2001. Alternative Methods to Examine Hospital Efficiency: Data Envelopment Analysis and Stochastic Frontier Analysis. *Health Care Management Science* 4: 103. doi:10.1023/A:1011453526849.

[2] O'Neill, L., M. Rauner, K. Heidenberger, and M. Kraus. 2008. Cross-national comparison and taxonomy of DEA-based hospital efficiency studies. *Socio-Economic Planning Sciences* 42: 158–189.

[3] Ruggiero, J. 2007. A comparison of DEA and the stochastic frontier model using panel data. *International Transactions in Operational Research* 14: 259–266.

[4] Karimi, S., H. Sajadi, M. Karami, L. Torkzad, and R. Bidram. 2009. Efficiency estimation in general hospitals of Isfahan University of medical sciences during 2005-2006 by data envelopment analysis. *Journal of Health Administration* 12: 39–46.

[5] Hollingsworth, Bruce. 2003. Non-parametric and parametric applications measuring efficiency in health care. *Health Care Management Science* 6: 203–218. doi:10.1023/A:1026255523228.

[6] Varabyova, Yauheniya, and Jonas Schrey??gg. 2013. International comparisons of the technical efficiency of the hospital sector: Panel data analysis of OECD countries using parametric and non-parametric approaches. *Health Policy* 112. Elsevier Ireland Ltd: 70–79. doi:10.1016/j.healthpol.2013.03.003.

[7] Verhoeven, Marijn, Victoria Gunnarsson, and Sergio Lugaresi. 2007. The Health Sector in the Slovak Republic: Efficiency and Reform. *Internacional Monetary Fund*: 27.

[8] Jafarov, Etibar, and Victoria Gunnarsson. 2008. Government Spending on Health Care and Education in Croatia: Efficiency and Reform Options. *International Monetary Fund*: 37.

[9] Mirmirani, Sam, H. C. Li, and Joseph A. Ilacqua. 2008. Health Care Efficiency In Transition Economies: An Application Of Data Envelopment Analysis. *International Business & Economics Research Journal* 7: 47–56.

[10] Grigoli, Francesco. 2012. Public Expenditure in the Slovak Republic: Composition and Technical Efficiency. *IMF Working Papers* 12: i. doi:10.5089/9781475505214.001.

[11] Borisov, D., C. Cicea, and C Turlea. 2012. DEA model for assessing efficiency in providing health Care. *Management Research and Practice* 4: 5–18.

[12] Neill, Liam O. 1998. Multifactor Efficiency in Data Envelopment Analysis with an Application to Urban Hospitals. *Health Care Management Science* 1: 19–27.

[13] Chirikos, Thomas N, and Alan M Sear. 2000. Measuring hospital efficiency: a comparison of two approaches. *Health Services Research* 34: 1389–1408.

[14] Rosko, M.D. 2001. Cost efficiency of US hospitals: A stochastic frontier approach. *Health Economics* 10: 539–551.

[15] Kirigia, J.M, A. Emrouznejad, and L.G. Sambo. 2002. Measurement of technical efficiency of public hospitals in Kenya: Using data envelopment analysis. *J Med Sys* 26: 39–45. doi:10.1023/B:JOMS.0000023298.31972.c9.

[16] Ramanathan, R. 2005. Operations assessment of hospitals in the Sultanate of Oman. *International Journal of Operations & Production Management* 25: 39–54. doi:10.1108/01443570510572231.

[17] Kiadaliri, Aliasghar A, Mehdi Jafari, and Ulf-G Gerdtham. 2013. Frontier-based techniques in measuring hospital efficiency in Iran: a systematic review and meta-regression analysis. *BMC health services research* 13: 312. doi:10.1186/1472-6963-13-312.

[18] Farzianpour, Fereshteh, Shayan Hosseini, Tahera Amali, Shadi Hosseini, and Sayed Shahab Hosseini. 2012. The Evaluation of Relative Efficiency of Teaching Hospitals Departmentof Health Management and Economics , School of Public Health , Tehran University of Medical Sciences , Tehran , Iran Department Management of Power and Energy , Faculty of Power and Ene. *American Journal of Applied Sciences* 9: 392–398.

[19] Kumbhakar, S.C., and C.A.K. Lovell. 2003. *Stochastic Frontier Analysis*. Cambridge: University Press.

[20] Frohloff, A. 2008. Cost and technical efficiency of German hospitals: Does ownership matter? *Health Economics* 17: 1057–1071. doi:10.1002/hec.1388.

[21] Lin, L C, and L A Tseng. 2005. Application of DEA and SFA on the measurement of operating efficiencies for 27 international container ports. *Proceedings of the Eastern Asia Society for Transportation Studies, Vol 5* 5: 592–607.

[22] Ravangard, Ramin, Nahid Hatam, Abedin Teimourizad, and Abdosaleh Jafari. 2014. Factors affecting the technical efficiency of health systems: A case study of Economic Cooperation Organization (ECO) countries (2004-10). *International journal of health policy and management* 3: 63–9. doi:10.15171/ijhpm.2014.60.

[23] Battese, G E. 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics* 20: 325–332. doi:10.1007/BF01205442.