Measuring the Technical Efficiency of Public Hospitals in Myanmar

Nan Nan Aung
Student, Master of Applied Statistics Program, Yangon University of Economics

Khin Thet Tun
Associate Professor, Yangon University of Economics

Dr. Mya Thandar
Pro-rector, Yangon University of Economics

Synopsis

- Estimating healthcare efficiency is a useful endeavor for Myanmar's health sector to attain optimal contributions from labor and capital investment in healthcare.
- This study aims to estimate the technical efficiency of Myanmar's public hospitals and examine the effects of labor and capital investment on hospital production using the Cobb–Douglas and the translog production function.
- The average technical efficiency of public hospitals over a 14-year period (2005–2018) is 93% and is slightly decreasing. The existing number of doctors and nurses can increase the maximum output of hospital production, and hospital beds have a substitutability effect in relation to midwives and other health staff.
- It is essential for policymakers to address decreasing hospital technical efficiency. Interventions for effective management of human and capital resources are proposed. The implementation of research at the hospital level is encouraged for more precise decision-making.

Introduction

The production function is a fundamental component of contemporary economies, health economists reference this construct when investigating the efficiency of hospital health care services. The term production function refers to the physical relationship between productive resources and results, in the form of goods or services per unit of time (Francisco et al., 2020). Health care costs are on the rise due to advanced care, emerging new diseases, and the implementation of quality improvement methods. Advancing health care efficiency is important for ensuring the optimal use of resources and prudently managing health care costs. Although measuring hospital productivity is challenging, it is essential to respond to the demand for hospital services and rising costs. A comprehensive hospital production function must also examine the economic viability of health care services and provide information for strengthening the health system. Myanmar, the second largest country in Southeast Asia, has a population of 55,109,033 (worldometer, 2022), representing 0.70**%** of the total world population. The proportion of the urban population is 31.40% and total health expenditure is 4.68% of gross domestic product (World Bank, 2019).

The study of healthcare efficiency at the southeast Asia region found that 91.3% of 46 countries were technically inefficient in using healthcare resources (Ahmed et al., 2019). The comparative study of technical efficiency taken among twenty-eight Asian countries found that eleven out of twenty-eight countries were technically efficient and Myanmar is in the list of inefficient countries (Win and Lofgren, 2020). Furthermore, the study of Myanmar health system from technical efficiency perspective is very rare, and no studies have been made on national level hospitals efficiency for estimating the hospital inefficiency frontier. Since public hospitals make up 80% of Myanmar's health system; this study aims to estimate the technical efficiency of public hospitals and measure the effect of input variables on the technical efficiency of public hospitals in Myanmar. Therefore, this paper will be presented materials and methods that used in this study, data analysis process, results, limitations of the study and concluded with recommendations.

Materials and Methods

The number of (in-patient and out-patient) patients in public hospitals in Myanmar were measured as the output variable, and the amount of health workforce and hospital beds were measured as input variables to estimate public hospitals' technical efficiency. The time series data over a 14-year period (2005–2018) were obtained from the Myanmar Statistical Yearbook, which is published by the Central Statistical Organization, Ministry of Planning, Finance and Industry. The data represent primary, secondary, and tertiary public hospitals across Myanmar. The number of doctors, nurses, and midwives were abstracted separately, as their composition is diverse in the health system and different institutions have varying expertise in caring for patients. Designations of dental surgeon, health assistant, lady health visitor, public health supervisor I, public health supervisor II, and indigenous medical practitioner are collectively presented as "other health staff."

Data Analysis

A descriptive analysis is used to explain the basic structure of study variables. The stochastic frontier model is commonly applied to estimate technical efficiency since it includes equation and measurement errors related to inefficiency (Coelli et al., 1998). Therefore, a stochastic frontier model, including Cobb–Douglas and the translog production function, are used to analyze hospital technical efficiency. From these two models, the best fit model is selected to examine the effect of output variables on the technical efficiency of public hospitals in Myanmar.

In stochastic form, the Cobb–Douglas production function is expressed as follows:

$$\ln (\text{Patients}) = \beta_0 + \beta_1 \ln \text{Bed} + \beta_2 \ln \text{Doctor} + \beta_3 \ln \text{Nurse} + \beta_4 \ln \text{Midwife} + \beta_5 \ln \text{Other Health Staff} + \varepsilon_i \quad (1)$$

The translog production function in stochastic form expressed as follows:

$$\ln (\text{Patients}) = \beta_0 + \beta_1 \ln \text{Bed} + \beta_2 \ln \text{Doctor} + \beta_3 \ln \text{Nurse} + \beta_4 \ln \text{Midwife} + \beta_5 \ln \text{Other Health Staff} + \beta_{11}\, 0.5 (\ln \text{Bed} \times \ln \text{Bed})$$

$$+ \beta_{22}\, 0.5\, (\ln \text{Doctor} \times \ln \text{Doctor}) + \beta_{33}\, 0.5\, (\ln \text{Nurse} \times \ln \text{Nurse})$$

$$+ \beta_{44}\, 0.5\, (\ln \text{Midwife} \times \ln \text{Midwife})$$

$$+ \beta_{55}\, 0.5\, (\ln \text{Other Health Staff} \times \ln \text{Other Health Staff})$$

$$+ \beta_{12}\, (\ln \text{Beds} \times \ln \text{Doctor}) + \beta_{13}\, (\ln \text{Bed} \times \ln \text{Nurse})$$

$$+ \beta_{14}\, (\ln \text{Bed} \times \ln \text{Midwife}) + \beta_{15}\, (\ln \text{Bed} \times \ln \text{Other Medical Staff})$$

$$+ \beta_{23}\, (\ln \text{Doctor} \times \ln \text{Nurse}) + \beta_{24}\, (\ln \text{Doctor} \times \ln \text{Midwife})$$

$$+ \beta_{25}\, (\ln \text{Doctor} \times \ln \text{Other Health Staff}) + \beta_{34}\, (\ln \text{Nurse} \times \ln \text{Midwife})$$

$$+ \beta_{35}\, (\ln \text{Nurse} \times \ln \text{Other Health Staff})$$

$$+ \beta_{45}\, (\ln \text{Midwife} \times \ln \text{Other Health Staff}) + \varepsilon_i, \qquad (2)$$

where

ln (Patients) = log of inpatients and outpatients

ln (Beds)= log of beds

ln (Doctors)= log of doctors

ln (Nurses)= log of nurses

ln (Midwives)= log of midwives

ln (Other Health Staff) = log of other health staff

β_0 = intercept of constant term

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = first order derivatives

$\beta_{11}, \beta_{22}, \beta_{33}, \beta_{44}, \beta_{55}$ = second order derivatives

$\beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}, \beta_{23}, \beta_{24}, \beta_{25}, \beta_{34}, \beta_{35}, \beta_{45}$ = cross order derivatives

The technical efficiency of public hospitals is tested using the following null hypothesis:

H_0: g = 0, the production function is technically efficient, and the alternative hypothesis, H_A: g ¹ 0, the production function is technically inefficient.

Results

Descriptive Method

Over the 14-year reference period (2005–2018), Myanmar's public health sector provided in-patient and out-patient services for a minimum of 3,761,000 and a maximum of 14,460,000 patients. Investment capital for hospital beds was allocated for a maximum of 61,811 available beds for admitted patients. The descriptive analysis (Table 1) shows that nurses are the highest proportion of the healthcare workforce in Myanmar's public health system followed by medical doctors, midwives, and other health staff.

Table 1. Descriptive Statistics of Output and Input Variables

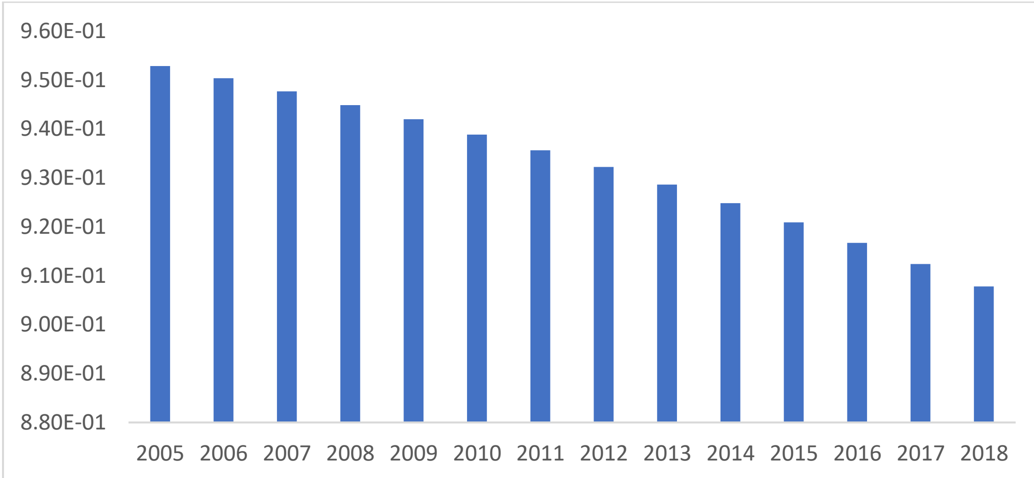
Variables	Mean	Standard Error	Standard Deviation	Minimum	Maximum
Patients	7,561,571	1,080,179.52	4,041,661.68	3,761,000	14,460,000
Beds	48,461	1,687.74	6,314.97	42,513	61,811
Doctors	22,266	1,971.57	7,376.95	8,436	32,861
Nurses	23,890	1,112.46	4,162.48	18,123	32,609
Midwives	17,987	745.96	2,791.16	13,651	22,258
Other Health Staff	12,763	1,007.98	3,771.51	8,615	18,875

Source: Myanmar Statistical Yearbook, Ministry of Planning, Finance and Industry (2020)

Stochastic Frontier Method

The maximum likelihood estimation of Cobb–Douglas and translog production models was calculated by using Frontier version 4.1 developed by Coelli (2009). In this study, the number of in-patients and out-patients was combined into total hospital output, as the standard stochastic frontier model allows only one output variable. The log-likelihood value from the two models was calculated to select the best fit model for the dataset, yielding values of 21.89 and 69.64 for Cobb–Douglas and translog models, respectively (Table 1). Since the higher the value of the log-likelihood, the better a model fits a dataset (Collie, 2005), the translog production model was selected to estimate the technical efficiency of public hospitals in Myanmar, revealing an overall technical efficiency of 93%, with a minimum of 91% and a maximum of 95%, gradually decreasing per year (Figure 1).

Figure 1: Hospitals' Technical Efficiency by Year (2005–2018)



Source: Frontier 4.1 output using data from the Myanmar Statistical Yearbook, Ministry of Planning, Finance and Industry (2020).

Table 2 presents the variables and parameters estimated using Cobb–Douglas and translog production functions. The variance ratio parameter, gamma (g) from the translog model is statistically significant, with a value close to one (0.99). The gamma value directed the presence of technical inefficiency in hospital production function. Moreover, the log-likelihood value of 235.85 is greater than the critical value of the Chi square of 35.556; thus, the null hypothesis, "health production function has no technical inefficiency," is rejected. These findings reveal evidence of technical inefficiency (u) in Myanmar's public health system, indicating that the difference in production is not only related to statistical noise. The gamma value of 0.99 suggests that high variability in hospital production is attributed to hospital technical efficiency and the remaining 1% is due to random noises.

Table 2. Parameter Estimates and Summary Statistic for Cobb–Douglas and Translog Production Function

Variables	Parameters	Cobb–Douglas	Translog
Constant	β_0	-39.395^{***}	32.2^{***}
ln (Beds)	β_1	3.277^{***}	34.7^{***}
ln (Doctors)	β_2	-0.355^{***}	-311^{***}
ln (Nurses)	β_3	-0.872^{*}	-574^{***}
ln (Midwives)	β_4	2.448^{***}	123^{***}
ln (Other health staff)	β_5	0.863^{***}	397^{***}
ln (Bed) × ln (Bed)	β_{11}		-105^{***}
ln (Doctor) × ln (Doctor)	β_{22}		-76.2^{***}

ln (Nurse) × ln (Nurse)	β_{33}		−168***
ln (Midwife) × ln (Midwife)	β_{44}		−26.7***
ln (Other Health Staff) × ln (Other Health Staff)	β_{55}		164***
ln (Beds) × ln (Doctor)	β_{12}		247***
ln (Bed) × ln (Nurse)	β_{13}		215***
Ln (Bed) × ln (Midwife)	β_{14}		−129***
ln (Bed) × ln (Other Health Staff)	β_{15}		−279***
ln (Doctor) × ln (Nurse)	β_{23}		215***
ln (Doctor) × ln (Midwife)	β_{24}		−12***
ln (Doctor) × ln (Other Health Staff)	β_{25}		−176***
ln (Nurse) × ln (Midwife)	β_{34}		160***
ln (Nurse) × ln (Other Health Staff)	β_{35}		−8.77***
ln (Midwife) × ln (Other Health Staff)	β_{45}		−18.5***
Sigma Square	σ^2	0.002***	147***
Variance Ratio Parameter (Gamma)	γ	0.000	0.99***
Log-likelihood		21.98	69.64
Technical efficiency		0.99	0.93

Note: *** and * represent 1% and 10% levels of significance, respectively.
Source: Frontier 4.1 output using data from the Myanmar Statistical Yearbook, Ministry of Planning, Finance and Industry (2020).

The sum of coefficients of input variables is greater than 1, and there is an increasing return to scale for hospital productivity. Elasticity in the number of beds, midwives, and other health staff is positive and statistically significant at the 1% level. The elasticity of doctors and nurses is negative and statistically significant at the 1%level (Table 2), which can be interpreted as the ability of the current number of doctors and nurses to maximize the hospital production function. All second and cross order coefficients in the translog model are statistically significant at the 1% level. The second order derivative shows changes in hospital productivity by squaring the inputs. Doubling the number of beds, doctors, nurses, and midwives could decrease hospital output by 105%, 76.2%, 168%, and 267%, respectively. This indicates that doubling the number of beds, doctors, nurses, and midwives would not maximize hospital productivity, whereas doubling the number of other health staff could increase hospital output when.

The cross-order derivative shows the interaction between the input variables. The coefficients of interaction between beds and doctors; beds and nurses; doctors and nurses; and nurses and midwives are significant and positive. The findings indicate that an increase in the number of beds would increase doctors and nurses; however, the number of beds has a substitutability effect for midwives and other health staff. If the number of doctors increases, the number of nurses should also increase, but substitutability should be considered concerning midwives and other health staff to optimize hospital production. If the number of nurses increases, the number of midwives should increase and substitutability with other health staff should be considered. Likewise, the substitutability between the number of midwives and other health staff should be considered for maximum hospital production.

Limitations

This study included the number of patients who engaged in-patient and out-patient services from public hospitals across Myanmar. However, due to lack of data availability, healthcare services provided in community and home-based settings could not be included. Thus, the services provided at all the public hospitals in Myanmar were collectively studied, and there may be an uneven distribution of health staff, as the number of patients may vary depending on the hospital facility (primary, secondary, and tertiary).

Conclusions

The technical efficiency of public hospitals during the study period (2005–2018) was slightly decreasing each year. This is a critical area for prioritization to address issues in a timely manner. Community level health services, health workforce, and capital investment should be considered in future investigations to comprehensively examine Myanmar's health system efficiency as a whole. These findings will benefit researchers and policymakers to estimate the country's health system performance. Health workforce numbers changed following the political crisis in 2021, and the technical efficiency of public hospitals should be reexamined using the currently active healthcare workforce to reflect the current circumstances of hospital production and to develop strategic remediation measures for maximum production. The translog production function analysis demonstrates substitutability between input variables that is useful for managing the production of health personnel to achieve optimum hospital production with minimum input. Policymakers should prioritize the production of different health professions according to existing production function needs and available budget. In conclusion, measuring health care efficiency is essential for strategic decision-making regarding investment of public health care resources. Implementation research is recommended for further expanding the measurement of efficiency so that hospital and policymaker decisions can be precise and specifically target actual public needs.

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