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What inefficiency distribution is 'generated' when behavior principle is given?: A short note on endogenous economic inefficiency modeling of municipal hospitals in Japan

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What inefficiency distribution is ‘generated’ when behavior principle is given?: A short note on endogenous economic inefficiency modeling of municipal hospitals in Japan

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Abstract

This note presents an attempt to check the shape of inefficiency distribution in stochastic frontier estimation, by regarding inefficiency as a consequence of some subjective equiibrium of economic agent. As an example, application to the cost data of municipal hospitals in Japan is considered. The influence of subsidy has been focused in this field. With simplified functional forms in which the role of subsidy is emphasized, we find the degree of defficit shrinkage by subsidy forms the distribution of cost inefficiency. We also check the distribution with actual data. The result seems compatible with the monotonic truncated inefficiency distribution. However, the result also implies the lower bound of the inefficiency should be reconsidered, as it is not zero.

1 Introduction

This short note attempts to provide an example of alternative measurement of inefficiency for the case of municipal hospitals in Japan. We asume hospital behavioral assumption, instead of inefficiency distribution in stochastic frontier analyses (SFA).

The standard procedure to analyze industry-mean inefficiency in SFA is to assume one of plausible inefficiency distributions such as half-normal or exponential (Aigner, Lovell and Schmidt (1977), Wim Meeusen and van Den Broeck (1977)). In their framework, the assumed inefficiency distribution summarizes all the latent information on inefficiency, including the mechanism through which the inefficiency is generated.

The biggest reason (except for goodness of fit to the data) for most SFA users to employ these distribution is that they are one-sided: A clearly consistent property with economic theory.

Then, do we have to leave everything beyond the one-sidedness to the goodness of fit? One of the possible theoretical approaches to this problem is to specify the mechanism that generates inefficiency. As summarized in Alvarez and Arias (2014) as

> However, equating inefficiency with poor management does not imply that the role of management in production is being correctly modelled.(Section 2.1, page 4)

understanding on behavioral principle of decision making unit (DMU) is essential. The widepread manner, which relates the predicted individual inefficiency to the exogenous covariates, helps to select relevant ineffiency factors. But the selection of the covariates often lacks theoretical background.

Building a model that generates inefficiency (that is, inefficiency is described as an endogenously determined equilibrium) for each industry is itself cumbersome. But once the mechanism is specified, individual inefficiency is determined as a function of exogenous variables. This function provides information not provided in usual two-step SFA. The former approach helps evaluation not only of the effect of various covariates, but also of behavior principle.

Inefficiency is observed because DMUs need to do something more than profit or cost optimization, not because we append inefficiency term to frontier. This may be the case especially in public utility or non-profit industries. Healthcare provision system in many coutries are typical examples. Moreover, in such industries, government financial aid is sometimes considered in the form of, say, subsidy, allowance, or lendng.

Previous studies on government-owned hospitals includes Rodríguez-Álvarez and Lovell (2004) which presents the expense preference behavior. A government hospital is described as a section of a government organization, so it maximizes its objective (utility) function under a given financial constraint. For municipal hospitals in Japan, Sano (2007) incorporates the role of subsidy to the hospital utility maximization model. [1] In these studies, hospitals are assumed to have preference on the quality of their service and financial status. [2]

In this note we try to numerically and visually understand the cost inefficiency distribution which emerges as a consequence of hospital utility maximization framework given in Sano (2007).

2 Methodology and Example

As an example of municipal hospital behavior model, let us consider Sano (2007) which emphasizes the effect of subsidy. The model is written in general form as:

Maximize

$$u = U(x, \pi^s), \tag{1}$$

with respect to x subject to

$$\pi^s = (1-s)\left(p(x) - w \cdot x\right). \tag{2}$$

The symbols are: x is a vector of input factors of production per bed. The per-patient revenue $p(x)$ is assumed to depend on x. y is the number of patients, and w is the input price vector. It is assumed that hospitals expect they receive subsidy proprtional to its (negative) profit. The proportion is exogenous to each hospital, and is denoted by s: Each hospital is assumed to know the level of s (Kornai (1979), Kornai (1986), Yamauchi (2009)).

The optimality condition of the hospital's subjective equilibrium is

$$\frac{\partial U}{\partial x} + \frac{\partial U}{\partial \pi} \cdot (1-s)\left(\frac{\partial p}{\partial x} - w\right) = 0. \tag{3}$$

Notice $\partial p/\partial x = w$ holds when $\partial U/\partial x = 0$ (or, equivalently, when $\partial U/\partial \pi \to \infty$). Large x implies affluent healthcare environment. As a consequence of the regulated industry, When $\partial p/\partial x < w$ as a consequence of the regulated industry, positive s works to offset the difference so that it equates to the hospital's money value of the affluent environment $(\partial U/\partial x)/(\partial U/\partial \pi)$.

For (3), we define three symbols: x^{ob} is the solution for given s and U. This corresponds to the observed x (with disturbance); x^{ns} is the hypothetical value of the solution when $s = 0$ and given U. This expresses what if there is no subsidy system; x^{nq} is the hypothetical value of the solution when $\partial U/\partial x \equiv 0$. This is the efficient x when structure aspect of the healthcare quality is ignored.

Corresponding cost predictions and inefficiency measures are also defined:[3]

[1] Though not in an explicit optimization form, Oshima and Ishida (2011) measures the imapct of subsidy on the cost structure in Japanese municipal hospitals.

[2] Rodríguez-Álvarez and Lovell (2004) and Sano (2007) rather focus on the structure (economic) aspect of the input resource allocation in hospitals, than overall quality considered in medical sciences (say, Donabedian (1966).

[3] These measures can be computed for every hospital in the sample, to form a distribution. In cost frontier models, the inefficiency term η is appended to the frontier function G in the form of $\log C = G + \eta$,

$$C^{\mathrm{ob}} = w \cdot x^{\mathrm{ob}} y,\ C^{\mathrm{ns}} = w \cdot x^{\mathrm{ns}} y,\ C^{\mathrm{nq}} = w \cdot x^{\mathrm{nq}} y, \tag{4}$$

$$I^{\mathrm{nq}} = \frac{C^{\mathrm{ob}} - C^{\mathrm{nq}}}{C^{\mathrm{nq}}},\ I^{\mathrm{ns}} = \frac{C^{\mathrm{ob}} - C^{\mathrm{ns}}}{C^{\mathrm{ns}}},\ I_0 = \frac{C^{\mathrm{ns}} - C^{\mathrm{nq}}}{C^{\mathrm{nq}}}. \tag{5}$$

When quality is not accounted for, I^{nq} is computed. I_0 is attributable to subsidy system: It is not avoidable as long as hospitals have preference on quality. The simple relation between these inefficiency measures:

$$1 + I^{\mathrm{ns}} = \frac{1 + I^{\mathrm{nq}}}{1 + I_0}, \tag{6}$$

implies that the usual measure I^{nq} should be discounted by the 'inevitable inefficiency' factor I_0 before interpretation.

In order to understand quantitavely, Sano (2007) assumes specific functional form. A modified version is:[4]

$$U(x_h, \pi_h^s) = \sum_i \alpha_i \log(x_{hi} - \theta_i) + \pi_h^s,\ p(x_h) = \beta_0 + \sum_i \beta_i x_{hi}. \tag{7}$$

The subscript h denotes hospital, and i denotes input. Then (3) yields

$$(\text{Observed Cost per Bed}) = A + B\frac{1}{1-s}, \tag{8}$$

$$I^{\mathrm{nq}} = \frac{\gamma}{1-s},\ I^{\mathrm{ns}} = \frac{s}{1-s} \cdot \frac{\gamma}{1+\gamma},\ I_0 = \gamma, \tag{9}$$

where $A = \sum_i w_i \theta_i$, $B = \sum_i \alpha_i/(w_i - \beta_i)$, and $\gamma = B/A$.

We check the distribution of I^{nq} using data from *Annual Statistics of Public Enterprises* (*Chihou Kouei-Kigyou Nenkan* in Japanese) Vol 61, edited by Local Public Financial Bureau, Ministry of Internal Affairs and Communications, the Government of Japan. This source reports data for 2013 fiscal year. We limit our sample to prefectural hospitals that report negative gross profit. We excluded those hospitals that receives more subsidy than its defficits ($s \in (0, 1)$). Final sample size is 37. The mean and standard deviation of $1/(1-s)$ are 0.58 and 0.08, respectively, with minimum of 0.50 and maximum of 0.85.

The distribution of $1/(1-s)$, which is proportional to I^{nq}, is shown in Figure 1. Since I^{ns} and I^{nq} satisfy the relation $I^{\mathrm{nq}} = (1+\gamma)I^{\mathrm{ns}} + \gamma$ in our example, the distribution of I^{ns} is expected to have smaller mean and variance than that of I^{nq} has.

The distribution seems nearly monotonic.[5] Those familiar simiple one-sided distributions such as half-normal and exponential work well as long as they have positive truncation point.

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and is assumed to have some one-sided non-negative distribution. The inefficiency indices defined in (5) are related to cost frontier inefficiency term η as $\eta = \log(1 + I)$.

[4]We introduced the minimum input parameter θ_i, and this prevents our model from having equilibrium inputs being zero. Marginal utility of π^s is also changed to constant in this note. We treat number of beds as production scale variable.

[5]Nevertheless, we better mention that there is another small mode around $1/(1-s) = 0.7$.

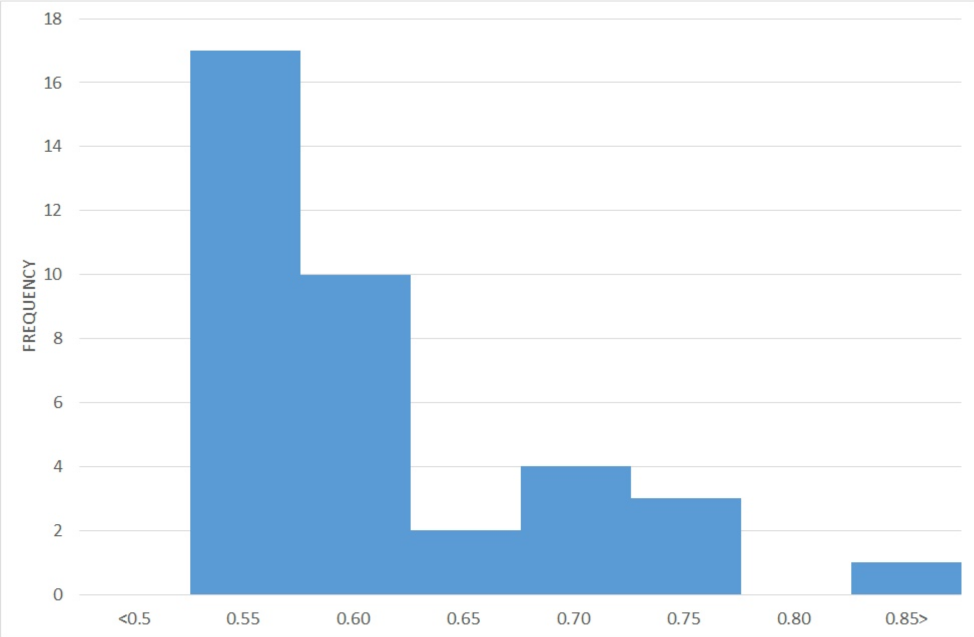

Figure 1: Distribution of $1/(1-s)$.

3 Remarks

Since in our methodology the only exogenous variable is s, the positive truncation is clearly determined by lower bound of s. The range is limited by our selection of sample to fit the model.

Actual distribution of s has wider range, and this should be the future research topic.

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