Panel Data Research Center at Keio University
DISCUSSION PAPER SERIES

DP2013-003
August, 2013

The Impact of the Designated Manager System of Japanese Public Halls: Measuring Technical, Allocative, and Productive Effeciency

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【Abstract】
This paper attempts to measure how the productive efficiency of Japanese public halls has changed following the introduction of the Designated Manager System (DMS). The DMS which was introduced for public halls around 2006 was intended to introduce market mechanisms into the public sector. In particular, we hypothesize that the DMS has forced the managers of public halls to be more cost conscious, leading to an improvement of the soft budget problem. That is, the production possibility frontier function for public halls is expected to shift outwards, and production inefficiencies would be smaller as a result of the introduction of the DMS. An unbalanced panel data set from 2004 to 2009 on 200, roughly 10 % of the total number of public halls, randomly chosen public halls was used to estimate a stochastic production frontier. It is found that the introduction of the DMS did lead to an upward shift of the production frontier, but it did not lead to any large change in the efficiency of production.

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Keywords: allocative efficiency, data envelopment analysis, designated manager system, productive efficiency, technical efficiency, stochastic frontier analysis.

JEL Classification Codes: H76, H32, D24

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[*] The author would like to thank Masaru Kaneko, Taisuke Katayama, Colin McKenzie, and Tamon Yamada for their helpful comments and suggestions.

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1. Introduction

In order to improve the financial inefficiencies in public sector by utilizing the vitality of the private sector, New Public Management (NPM) has started in the United Kingdom and New Zealand in 1980s. Similarly, the *Koizumi* Government undertook structural reforms from 2001 to try to solve the soft budget problem in the public sector. As a result, Japan moved towards a smaller government and some parts of the public sector were privatized. The introduction of the Designated Manager System (DMS) for certain public facilities is one part of these structural reforms. The three main purposes of the DMS were: to reduce the public deficit; to reduce the covering of the deficits of the public facilities by local governments after losses have been incurred; and to introduce private management methodologies into public facilities. Public facilities that became the subject of the DMS include: public facilities for art and culture, sewerage disposal plants, airports, gymnasia and libraries. The DMS is related to an Article 244 of the Local Autonomy Law (*Chihouzichi Hou*), "public facilities (*Ooyake no Shisetsu*)". In order to enable all public facilities to select the private manager as designated managers, the Article 244 of the Local Autonomy Low was changed in June 6, 2003 and enacted among several public halls in September 2, 2003. Then, the Article 244 of the Local Autonomy Law entirely enacted among the other public halls in September 3, 2006. (Local Autonomy Act 244) Therefore, it can be said that the DMS was introduced into public halls in 2006.

No Japanese law defines what public hall is. Generally, it was considered that there was a lot of wasteful expenditure associated with Japanese public halls (for example, Kobayashi (2006), P.P. 24 - 26), so it was rather natural that the DMS was applied to public halls as well. In this paper, the definition of a "public hall" is any facility which belongs to the Association of Public Theaters and Halls in Japan (*Zenkoku Kouritsu Bunka Shisetsu Kyougikai*, also known as *Kou Bunn Kyou*), and includes, for example, community centers, music halls, all-purpose halls, theaters, and libraries with halls. The number of public halls in Japan increased rapidly following the expansionary Keynesian fiscal policy of the 1990s. This increase in the number of public halls was considered as having the merit of providing a "fairer" distribution of art and cultural goods, not only for people living in city areas, but also for those people living in country areas. A potential disadvantage of this policy was an increase in the inefficiency in the public sector. Since 2000, the construction of public halls has continued, and there are now about 2200 facilities in total.

This paper aims to assess the economic effect of the introduction of the DMS on

Japanese public halls by estimating an efficiency indicator. There are three areas of existing research that are related to this paper: general assessments of the management of public facilities; research related to the DMS system; and the measurement of inefficiency via the estimation of a production possibility frontier, .

There are several papers evaluating the management of public facilities like public libraries, public theaters or university libraries using some sort of efficiency approach like a Stochastic Frontier Approach (SFA) and/or a Data Envelopment Approach (DEA) (see, for example, Tamura (2002), Reichmann (2004) and Last and Wetzel (2009)).. Important issues in this research are how to define the "output" of the public facility, and how to take account of any positive externalities associated with the facility. There are examples where the output of a facility is treated as the utilities of consumers, and the Contingent Valuation Method (CVM) is used to measure positive externalities. Some examples of research measuring inefficiency in the public sector via SFA &/or DEA approaches include: Tamura's (2002) application to book lending in Japanese public libraries, and which interestingly enough included the number of volunteers as one of inputs because there are a sizeable number of volunteers in Japanese public libraries; Reichmann's (2004) application to university libraries in Germany, Austria, Switzerland, the United States, Australia, and Canada; and Last and Wetzel's (2009) application to German public theaters. These three papers examined the existence of inefficiencies and measured them.

Rather than providing data based on evaluations, many of the existing studies of the Japanese DMS tend to discuss ideological matters. Nakaya (2005) summarized the situation facing public halls before the DMS was introduced, and pointed to the importance of assessing the work of designated managers after the DMS was introduced Nakaya's (2005) book has become a kind of handbook for local governments and art managers. From the view point of political sociology, Kobayashi (2006) pointed out the difficulties in assessing the activities in the cultural sector and considered the problems that might arise after the introduction of the DMS. Cultural Policy Network edi. (2004) estimated the changes in public cultural facilities in Japan after the introduction of the DMS. Kobayashi (2006) writing right at the time the DMS was introduced expressed negative opinions concerning economic assessments of public facilities via economic indicators because they think that the public facilities for art and culture have some value which are not measurable by economic indicators. Nakagawa and Matsumoto (2007) also expressed their negative opinion against the assessment of the DMS using economic techniques. While this is certainly true, policies for art and culture that totally ignore profit or cost considerations are unrealistic. There are no existing studies which evaluate the introduction of the DMS to pubic halls. Using economic indicators can be very useful when drafting realistic policies with regard to the cost of these facilities. This is the first attempt to measure the efficiencies of public halls before and after the DMS.

The third and final area of related research focuses on measuring inefficiency of firms via the estimation of a production function. The econometric methods used are parametric, semi-parametric, and non-parametric approaches. The standard parametric approaches are known as Stochastic Frontier Analysis (SFA) and Corrected Ordinary Least Squares, (COLS), while the standard non-parametric approach is known as Data Envelopment Analysis (DEA). This study uses both the parametric SFA and the non-parametric DEA approaches, and measures technical, allocative and productive inefficiencies. SFA was developed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) in the economics area, while DEA is developed by Charnes et al. (1978) in an operations research context. Given their respective advantages and disadvantages, SFA and DEA can be viewed as being complementary. For instance, one of the key disadvantages of DEA is that it does not allow for hypothesis testing whereas SFA does. One of the disadvantages of SFA is the need to assume a specific form for the productive function and a specific distribution for the inefficiency component, while DEA does not require these assumptions. Combining the three inefficiency indicators proposed by Farell (1957) with SFA or DEA enables inefficiency decompositions to be undertaken.

It is worth noting that the measurement of inefficiency is usually undertaken for firms in the private sector, but there are examples of applications to the public sector. For example, Nakayama (2002) measures inefficiency in the water processing and sewerage in Japan, via both SFA and DEA, Goto (2002) measures the efficiency of the electric industry, especially the electricity supply network, in the United States via SFA.

The key contributions of this paper are the construction of a unique data set for Japanese public halls; the estimation of a production function for Japanese public halls; and the measurement of the productive, technical, and allocative efficiencies of Japanese public halls via both SFA and DEA. This is the first application of SFA and DEA to public halls in Japan.

The rest of this paper is organized as follows. Section 2 presents the background relating to why the DMS was introduced for public halls in Japan. In this section, Section 3 provides an explanation of the methodology used to measure inefficiencies. Section 4 gives detail of the data used in this paper. Section 5 presents the empirical results. Section 6 contains some concluding remarks. An Appendix provides a simple econometric model to explain the relationship between the public financial power of local government authorities and their selection of the DMS.

2. The Introduction of the DMS for Japanese Public Halls

Prior to the introduction of the DMS, the Entrusted Manager System (EMS) existed. The EMS enables a local government to choose either the direct management of a public facility or the management of the facility by an extra-government organization of the local government. The EMS has a less characteristic of the New Public Management than DMS. The key difference between the EMS and the DMS is that the DMS enables private managers to be employed to manage the public halls. In 2006, the DMS introduced to public halls except the case of the testing introduction. One of the important purposes of the introduction of the DMS is to reduce the financial deficits of local governments in Japan. Before the introduction of the DMS, local governments cover the deficits for the management of public halls. That is the reason why the managers of public halls were not conscious of costs and there were a lot of inefficient managements in public halls. However, by adopting the management methods of the private sector, the facilities may become more cost conscious. Even if the managers of a facility do not change, the management of public halls has potentially changed because the DMS has also fixed or reduced the budgets for public halls. Thus, the DMS can make the management of public sector more efficient.

Table 1 shows that by 2007 about 34% of the facilities for art and culture introducing the DMS in 2007. To be more concrete, there were about 2700 facilities that were managed directly, and about 1300 facilities which had introduced the DMS by 2007. As shown in Table 2, the facilities which had previously introduced the EMS also tend to be those that have introduced the DMS, while the facilities which had been under direct management by the local government tend to have not introduced the DMS. In many cases, the switch from the EMS to the DMS has not result in a change in the manager of the facility from a local government or their affiliated organizations to private organization.

Table 1: Adoption of Designated Manager System by Public Facilities for the Arts and Culture (includes not only public halls but also other public cultural facilities)

	Percentage of Facilities Adopting DMS	Manager Type	
		Public	Non-public
Prefectural facilities	68.9%	65%	35%
Facilities of Cities Designated by Ordinance	79.2%	61%	39%
Facilities of Municipalities except Cities Designated by Ordinance	28.2%	27%	73%
Total	34.2%	37%	63%

Notes: The total number of facilities is 4,265. After the elimination of facilities that did not answer the survey or provided unclear answers, the sample size is 4,177. This sample includes not only public halls, but also other public facilities for the arts and culture.

Source: This table was constructed using survey data reported in i Japan Foundation for Regional Art-Activities (2007)

Table 2: Impact of the Introduction of the Designated Manager System for Public Facilities for Art and Culture; By Management Type

Pre-DMS		Post-DMS		Public/Non-Public Division	
Management Type	Number	Management Type	Number (Percentage)		
Direct Management	2782	Direct Management	2636 (94.8%)	Public	2636 (100.0%)
		Designated Manager	146 (5.2%)	Public	83 (56.8%)
				Non-public	63 (43.2%)
Entrusted Manager	1279	Direct Management	78 (6.1%)	Public	78 (100.0%)
		Designated Manager	1201 (93.9%)	Public	410 (34.1%)
				Non-public	791 (65.9%)
New	116	Direct Management	57 (49.1%)	Public	57 (100.0%)
		Designated Manager	59 (50.9%)	Public	35 (59.3%)
				Non-public	24 (40.7%)

Source: as for Table 1

The results presented in Appendix 1 indicate the financial power of the local government controlling the facility is a good explanatory of whether or the facility adopts the DMS, and, in particular, show that local governments with strong financial positions tend to be the ones that adopt the DMS for their facilities. This result implies that the local governments which have weak financial power tend not to introduce the DMS.

3. Method

In order to examine the impact of the DMS on public halls, we estimate a production function for these facilities that allows for inefficiencies. This production function is estimated using both the SFA and DEA approaches. Given estimates of these production functions, it is then possible to compute the inefficiency indicators proposed by Farell (1957).

3. 1 Farell's (1957) Definition of (In)-Efficiency

The idea of inefficiency indicators was first proposed by Farell (1957) and his method has become the most popular method of measuring inefficiency. This decomposing way is shown clearly by Kopp and Diewert (1982). Farrell classifies inefficiencies into three types: technical efficiency (TE), allocative efficiency (AE), and productive efficiency (PE). A simple example, assuming two inputs and one output case, is used to illustrate these three concepts. Both Figure 1 and 2 shows a frontier unit isoquant for technology (SS') and a point of inefficient activity denoted by X^A. X^A is obviously inefficient because it does not lie on SS'. The point X^B is defined as a point of intersection of the line segment OX^A with the isoquant curve SS'. The line segment PP' is denoted as the minimum isocost line which goes through the most efficient point denoted by X^E. The point X^C is defined as the point of the intersection of the line segment OX^A with the line segment PP'. X^C is a point that achieves the same minimum cost as X^E which achieves most efficient allocation of input. In this case, Farell's (1957), three efficiency indicators, technical efficiency (TE), allocative efficiency (AE), and productive efficiency (PE), are defined as follows:

$$TE \equiv OX^B/OX^A \quad (1)$$

$$AE \equiv OX^C/OX^B \quad (2)$$

$$PE \equiv OX^C/OX^A. \quad (3)$$

While Figure 1 presents the case of a smooth frontier unit isoquant for technology (SS'), Figure 2 illustrates the case where the frontier unit isoquant for technology (SS') is a series of line segments (as is generated by DEA analysis). Figure 1 and Figure shows that how to decompose PE into TE and AE is the same in both SFA and DEA.

Figure 1: Definition of Inefficiency Indicators via SFA

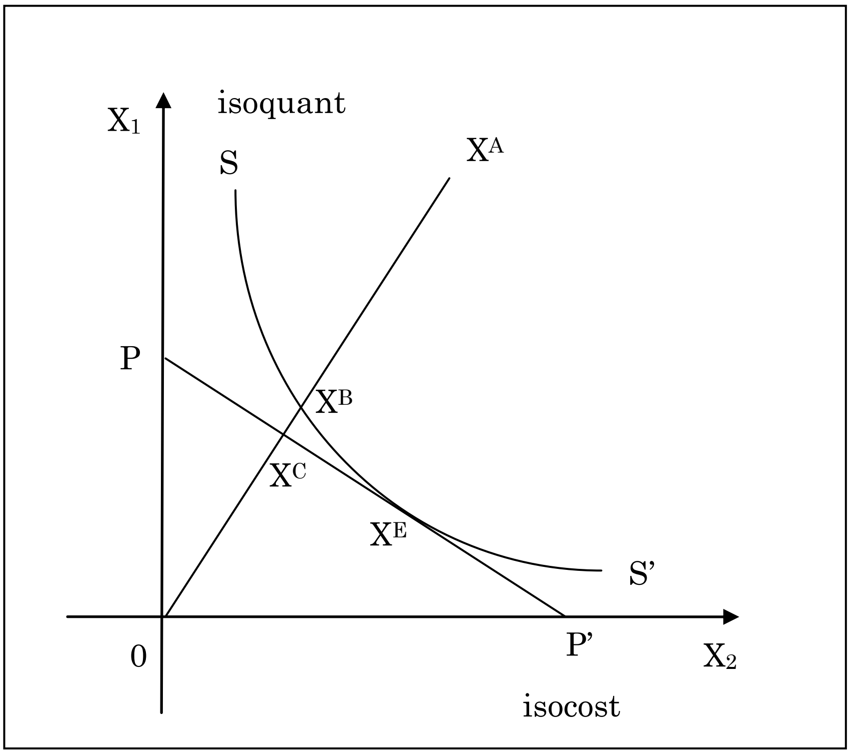
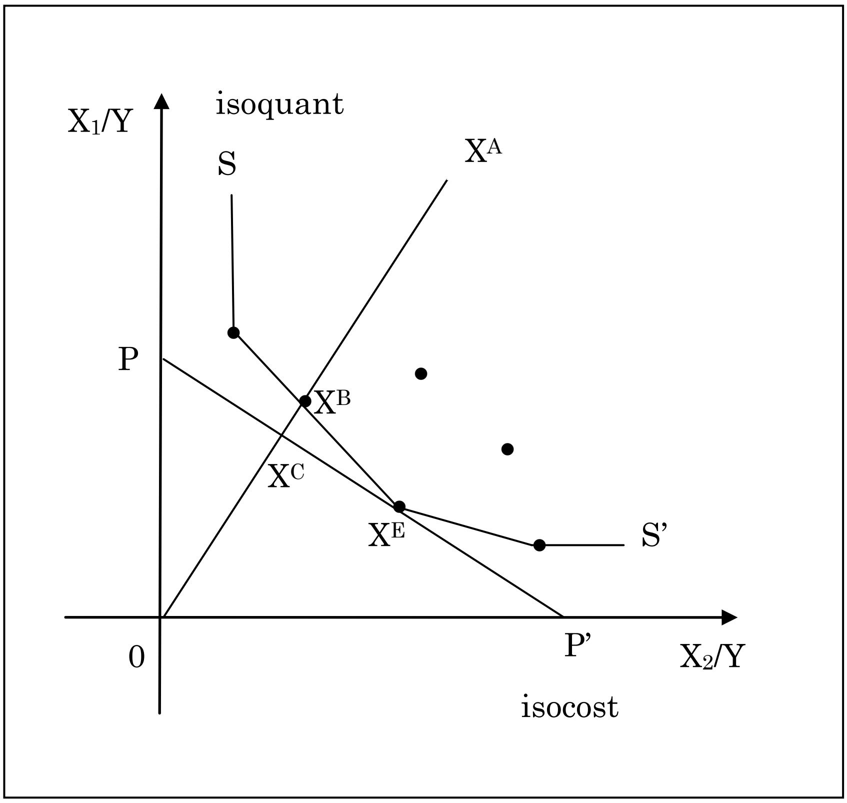


Figure 2: Definition of Inefficiency Indicators for Input-Orientated DEA



3. 2 Using SFA to Measure Efficiency

The basic idea for the measurement of efficiency indicators obtained using Stochastic Frontier Analysis (SFA) and using input-orientated Data Envelopment Analysis (DEA) is essentially the same. That is why Nakayama (2002) measured the three kinds of inefficiencies of the waterworks in Japan via SFA and DEA. Here, we first explain the SFA approach and then the DEA approach.

Assume there are K inputs and one output, and that the inputs and outputs are related by a Cobb-Douglas type of production function, where the constant returns to scale is assumed. Then, the stochastic production possibility frontier can be written as the follows:

$$\ln y_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k \ln x_{kit} + v_{it} - u_{it} \quad (4)$$

where y_{it} is the output of the i-th public hall in year t, x_{kit} is the k-th input of the i-th public hall in year t, v_{it} is a standard disturbance term that is assumed to follow a normal distribution with mean 0 and variance σ_v^2, and u_{it} is assumed to follow a half normal distribution with mean 0 and variance σ_u^2. In this model, u_{it} is an indicator of inefficiency. Until the null hypothesis of σ_u^2=0, all public halls are efficient producers.

Subtracting v_{it} from both sides of equation (4) gives

$$\ln \widetilde{y_{it}} = \ln y_{it} - v_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k \ln x_{kit} - u_{it}, \quad (5)$$

where $\widetilde{y_{it}}$ is output after the removal of the stochastic noise. The technically efficient input levels for producing $\widetilde{y_{it}}$, x_{kit}^T, can be calculated using (5) and the following equation:

$$x_{kit}/x_{1it} = r_{kit}, \quad k \neq 1, \quad (6)$$

where r_{kit} is the ratio of the observed value of the k-th input to the observed value of the first input.

If the production frontier function is given, a dual cost function can be obtained by solving the cost minimization problem. In the case of the Cobb-Douglas production function, the dual cost function is given by:

$$\ln C_{it} = \delta_0 + \sum_{k=1}^{K} \delta_k \ln w_{kit} + \delta_y \ln \widetilde{y_{it}}, \quad (7)$$

$$\delta_0 = \ln\left(\sum_{k=1}^{K} \beta_k\right) - \left(\beta_0 + \ln\left(\prod_{k=1}^{K} \beta_k^{\beta_k}\right)\right) / \sum_{k=1}^{K} \beta_k, \quad (8)$$

$$\delta_k = \beta_k / \sum_{k=1}^{K} \beta_k, \quad (9)$$

$$\delta_y = 1 / \sum_{k=1}^{K} \beta_k, \quad (10)$$

where C_{it} is the optimum cost for the i-th public hall in year t, and w_{kit} is the observed price of the k-th input factor for i-th public hall in year t. From equation (7) and Shepard's lemma, the following equation can be obtained.

$$\frac{\partial C_{it}}{\partial w_{it}} = \delta_k w_{kit}^{-1} C_{it} = x_{kit}^E, \quad (11)$$

where x^{E}_{kit} is the productive efficient level of the k-th input. As a result, following Farell (1957), technical efficiency, allocative efficiency, and productive efficiency can be calculated using the following equations:

$$TE^{SFA}_{it} = \sum_{k=1}^{K} w_{kit}x^{T}_{kit} / \sum_{k=1}^{K} w_{kit}x_{kit} \ , \tag{12}$$

$$AE^{SFA}_{it} = \sum_{k=1}^{K} w_{kit}x^{E}_{kit} / \sum_{k=1}^{K} w_{kit}x^{T}_{kit} \ , \tag{13}$$

$$PE^{SFA}_{it} = \sum_{k=1}^{K} w_{kit}x^{E}_{kit} / \sum_{k=1}^{K} w_{kit}x_{kit} \ . \tag{14}$$

3.3 Using DEA to Measure Efficiency

For the measurement of inefficiency using DEA, the input-orientated DEA model is used because a one output model is used in this study. As a result, only the input-orientated DEA model is explained in this paper.

For the case of Variable Return to Scale (VRS) cost minimization, the input-orientated DEA model sets out to solve the following equations.

$$\min \theta \ (= TE^{DEA}_{i})$$

$$s.t. -y_{it} + Y\lambda \geq 0$$

$$\theta x_{it} - X\lambda \geq 0$$

$$e1'\lambda = 1$$

$$\lambda \geq 0, \tag{15}$$

where y_{it} is an output vector for the i-th facility, x_{it} is an input vector for the i-th facility, Y is the $M \times N$ output matrix for M outputs and all N facilities, X is the $K \times N$ input matrix for K inputs and all N facilities, θ is a scalar, λ is a $N \times 1$ vector of constants and e1 is an $N \times 1$ vector of ones. In this case, θ is an estimate of technical efficiency (TE).

Next, for the cost minimization DEA model the following equations are solved:

$$\min w_{it}' x_{it}^{E}$$

$$s.t. -y_{it} + Y\lambda \geq 0$$

$$x_{it}^{E} - X\lambda \geq 0$$

$$e1'\lambda = 1$$

$$\lambda \geq 0 \tag{16}$$

where w_{it} is a vector of input prices for the i-th public hall and x_{it}^{E} (which is calculated by the linear programming problem) is the cost-minimizing vector of input quantities for the i-th facility, given the input prices w_{it} and the output levels y_{it}.

The productive and allocative efficiencies of the i-th facility can be calculated as follows:

$$PE_{i}^{DEA} = w_{it}' x_{it}^{E} / w_{it}' x_{it} \ , \tag{17}$$

$$AE_{it}^{DEA} = PE_{it}^{DEA} / TE_{it}^{DEA}. \tag{18}$$

DEA does not allow us to explicitly take into consideration the panel nature of the data, so this is one of the factors which might lead to different estimates of inefficiencies when SFA and DEA are used.

3.4 Estimated Models

When the SFA is adopted, to allow for time variation in the model for inefficiency, a Time Variant Decay (TVD) model defined in equation (20) is used in addition to a Time Invariant (TI) model defined in equation (19).as follows are used:

TI Model

$$\ln Q_{it} = \alpha \ln K_{it} + \beta \ln L_{it} + \gamma + \delta dms_{it} - u_i + v_{it}, \ \ u_i \sim N^{+}(\mu, \sigma_{\mu}^{2}), \ \ v_{it} \sim N(0, \sigma_{v}^{2}) \tag{19}$$

TVD Model

$$\ln Q_{it} = \alpha \ln K_{it} + \beta \ln L_{it} + \gamma + \delta dms_{it} - u_{it} + v_{it}, \ \ u_{it} = \exp\{-\eta(t - T_i)\} u_i$$

$$u_i \sim N^+(\mu, \sigma_\mu^2),\ v_{it} \sim N(0, \sigma_v^2), \qquad (20)$$

where Q_{it} is the number of events produced by the manager of the i-th public hall in year t, K_{it} is the quantity of capital used for events by the i-th public hall in year t, L_{it} is the quantity of labor used for events by the i-th public hall in year t, dms_{it} is dummy variable taking the value of 1 if at time t the public hall i has adopted the DMS, and 0 otherwise, v_{it} is standard disturbance. In equation (19), u_i is a measure of technical inefficiency, and in equation (20) u_{it} is a measure of technical inefficiency. As can be seen from the model relating u_{it} and u_i in equation (20), this relationship allows for changes in efficiency over time. If $\eta = 0$, equation (20) collapses to equation (19). If the null hypothesis of $\sigma_\mu^2 = 0$ is accepted, there is no inefficiency. In this case, the fixed-effects and random-effects models are also estimated. By the way, in testing whether the variance of η is zero or not, we need to be aware that under the null hypothesis that the variance of η is zero, the parameter is on the boundary of the parameter space, so that Wald tests and Likelihood ratio tests of the null hypothesis do not have standard chi-square distributions. However, even when we take account of Andrews' [2001] results, we find that the null hypothesis that the variance of η is zero is clearly rejected. When the DEA is used, the input-orientated Variable Returns to Scale (VRS) model is used (see, Nakayama (2002) for an example).

4. Data

The data used in this paper was obtained utilizing the provisions of Japan's Freedom of Information Laws, namely, the "Act on Access to Information Held by Administrative Agencies' (*Gyousei kikan no hoyuu suru jouhou no koukai ni kansuru houritsu*) and 'Organs Law Concerning Access to Information held by Incorporated Administrative Agencies, Etc.' (*Dokuritsu gyousei houjin nado no hoyuu suru jouhou no koukai ni kan suru houritu*)],. This laws create a system that provides guaranteed access to certain information held by the public sector (*Jouhou koukai seido*). The data on Local governments whose financial power is weak tend to limit the people who can make use of the freedom of information procedures to people who have lived in their own local government area. When the author was not qualified to access the relevant information, the information was requested by questionnaires.

Rather than requesting data on every public hall in Japan, around 2000 institutions, requests were made to the appropriate local government authorities for information on 200 randomly chosen public halls. The sample of 200 is roughly 10 % of the total number of public halls in Japan. As a result of the freedom of information requests, an unbalanced panel data set consisting of annual data from 2004 to 2009 on these 200 public halls could be constructed.

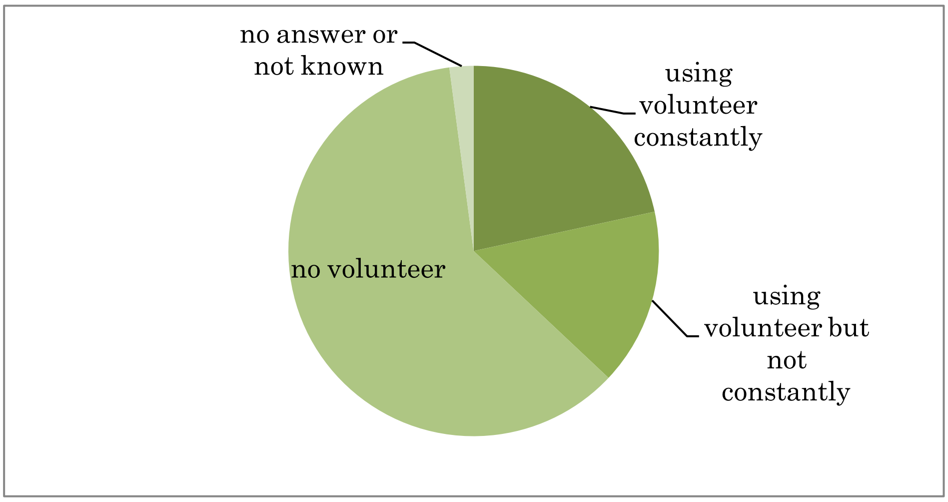
In order to estimate the quantity of capital from the data provided, it was necessary to have a measure of the cost of capital,. Two definitions of the cost of capital are employed. The first is the Usercost (UC) of the building defined as

$$\mathrm{UC} = \mathrm{i} + \mathrm{D} - \dot{\mathrm{P}}/\mathrm{P} \quad , \tag{24}$$

where UC is the usercost, i is the interest rate for loan payments, D is the rate of depreciation, and $\dot{\mathrm{P}}/\mathrm{P}$ is the rate of increase of the value of land (*Koujitika*). The second definition of the cost of capital comes from the Total Average of the Price Indicator of Service for Corporations except Consumption Tax (*Shouhizei wo nozoku kigyoumuke service kakaku shisu no souheikin*). Table 3 reports descriptive statistics for two cases, when the price of capital is estimated using the usercost concept, and when the price of capital is estimated using the price indicator of services. The number of capital, K is calculated by $\mathrm{K} = (\text{the total number of labor wages})/(\text{the price of capital})$.

There are three main problems that need to be considered when efficiency indicators are applied to public halls. The first problem is how the "output" of public halls should be defined. Throsby and Withers (1979) refer to the difficulties in defining the output of the performing arts. One of the Throsby and Withers (1979)'s definitions is used in this paper. In theory, hall rentals and the number of events offered could be considered to be the two main measurable outputs of Japanese public halls. In this paper, estimates of inefficiencies using the number of events are reported because detailed data on hall rentals are not available. The second difficulty is how to treat temporary employees and volunteers which are a characteristic of the public sectors. In the case of Japanese public halls from 2004 to 2009, it is assumed that the level of temporary employees and volunteers is negligible, because they are not substitutable for regular staff (see, for example, the survey of Research Institute of Industry and Regional Economy (2006)). Figure 3 shows that 60.9 % of public halls used no volunteers in 2007. Though 21.6 % of public halls used volunteers constantly (Figure 5), the main tasks of volunteers are as receptionists, ushers, or the staff in halls (see Figure 4). The third problem is how to standardize the balance sheets of public halls as individual public halls have various formats for their balance sheets. If inputs are simply divided into capital and labor, all balance sheets can be standardized.

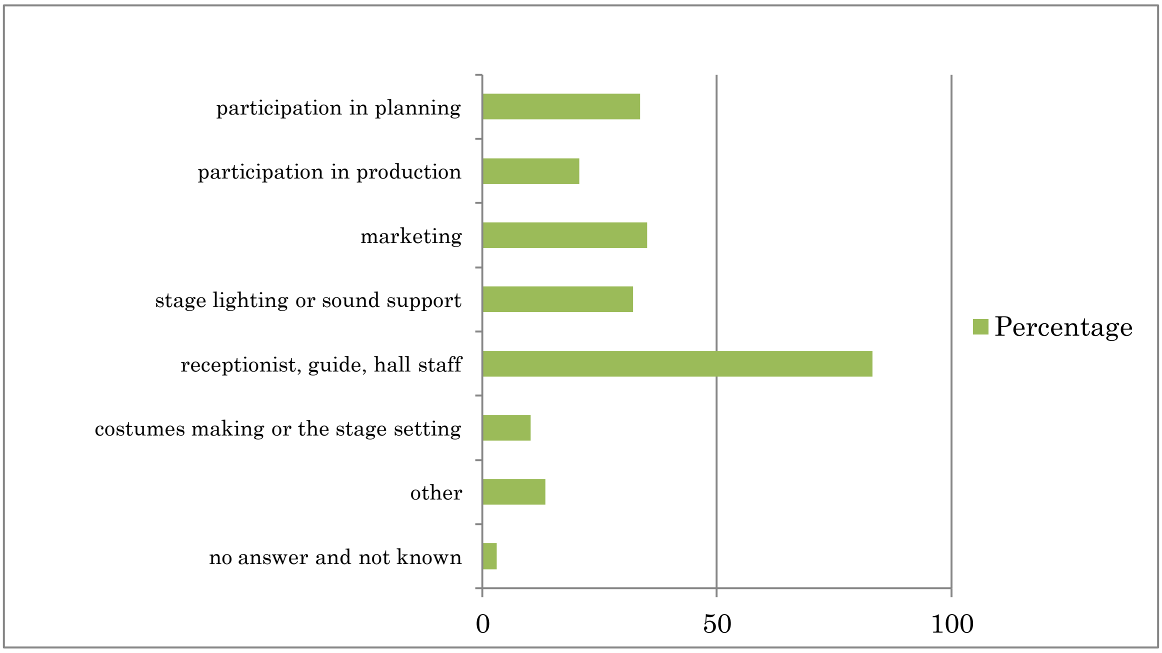
Figure 3　Details of Public Hall　Usage of Volunteers



The total number of public halls which supply cultural events is 1211.

Source: as for Table 1

Figure 4: The Kinds of the Works for the Regular Volunteers



The total sample size is 262.

Source: as for Table 1

Table 3: Descriptive Statistics

r=usercost

Variable	Total	With DMS	Without DMS
wL	88882.77	103231.80	80980.39
rK1	84140.73	89721.32	81067.36
w	6677.322	6708.661	6660.063
L	14.168	17.184	12.507
r1	0.126	0.102	0.140
K1	1290880	1925996	941106.1
Q	26.86	36.76	21.399
Sample Size	214	76	138

r=price

Variable	Total	With DMS	Without DMS
wL	83476.26	31367.21	75115.57
rK2	71781.61	1575.068	70303.49
w	6293.214	2828.724	6336.095
L	14.026	17.565	11.90625
r2	93.774	93.797	93.640
K2	766.955	16.796	752.800
Q	25.111	7.984	20.338
Sample Size	232	62	160

Note: When the usercost is used to measure r, the sample size is reduced because cases where the usercost is estimated to be negative are dropped from the analysis.

5. Results and Discussion

STATA Version 10 was used to estimate the SFA models, and DEAP Version 2.1 developed by Coelli (1996) was used.to obtain the inefficiency estimates using the DEA approach,

Table 4 and 5 present estimates of the production function using the stochastic frontier approach assuming Time Invariant inefficiency (TI) (Models 2, 5, 8, and 11) and Time Variant Decay (TVD) inefficiency (Models 3, 6, and 9), estimates of the production function assuming fixed effects (Models 1, 4, 7, and 10). These panel models which do not explicitly include inefficiency terms may be more suitable than SFA models when the tests for inefficiencies in the SFA model suggest there are no inefficiencies. If the existence of inefficiency is accepted, TI SFA or TVD SFA model are supported.

Examining the results for the parametric models in Table 5 indicates that with the exception of the coefficients in the fixed effect model, all the estimated coefficients associated with the two inputs are positive. In all the fixed effect models, the estimated coefficients of $\ln L$ are negative, but not statistically significant. These results suggest the fixed effect model does not provide good estimates of the production function, or that labor is irrelevant for the purposes of changing output.

Models 1-6 contain the DMS dummy variables to examine whether or not the production function for public halls shifts for those halls introducing the DMS, while Models 7-12 do not contain the DMS dummy variables. In all models containing the DMS dummy, the estimated coefficients of the DMS dummy are positive and significant. This suggests that the introduction of the DMS seems to have shifted the production frontier outwards, that is, more output is achieved for the same inputs of labor and capital as a result of introducing the DMS.

When the results for the TI and TVD models are compared, the TI model appears to be the more acceptable model. The results for Models 3, 6 and 9 suggest that the TI models are supported because the estimates of η are all statistically insignificant. Therefore, Models 8 and 11 are used to compare the estimates of the three efficiency indicators. In order to measure the impact of the DMS as the inefficiency terms, the model without the DMS dummy are used here. Given the different definitions of the price of capital, the models using different estimates of the level of capital are non-nested. In choosing between these models, it should be noted that the estimated skewness of u, 3.70 where price is used is closer to the skewness of half-normal distribution assumed, 3.36, than the estimated skewness of u, 4.34, when usercost is used as the data for the price of capital (Table 7). Because the distribution of the inefficiency term has strong assumption, the model which has more relaxed assumption is considered more appropriate. Therefore, Model 11 used for the calculation of three efficiency terms.

The estimates of the efficiency indicators for both the SFA (Model 11) and DEA approaches are shown in Table 6. The estimates for 'Total' are the average efficiency estimates for all public halls at all points in time. The estimates for 'With the DMS' and 'Without the DMS' are, respectively, the average efficiency estimates for all the public halls after they introduced the DMS, and the average efficiency estimates for the public halls that did not introduce the DMS and public halls before they introduced the DMS. The results obtained for the SFA method using different estimates of r are consistent except Productive Efficiency (PE). Estimates of Technical Efficiency (TE) and Allocative Efficiency (AE) obtained using DEA are consistent with the estimates of TE and AE obtained using SFA and support the robustness of the SFA-based estimation. The results in Table 6 suggest that after the introduction of the DMS Technical Efficiency (TE) worsened, while Allocative Efficiency (AE) improved after the introduction of the DMS. Productive Efficiency (PE), the total effect of TE and AE, remained in the result of SFA, while PE worsened in the result of DEA. There is no doubt that Productive Efficiency (PE) did not improve. One reason for the worsening of Technical Efficiency may be that the facilities that have introduced the DMS tended to spend more on each event. On the other hand, steps to cut labor costs step by step may have contributed to improvements in Allocative Efficiency.

Table 4: Results for Stochastic Frontier Analysis:r=usercost

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Estimation Method	Fixed-Effects	TI	TVD	Fixed-effects	TI	TVD
lnK2	-0.008	0.021	0.028	0.072	0.132	0.132
(r=price)	(0.029)	(0.028)*	(0.028)*	(0.066)	(0.050)	(0.048)*
lnL	-0.136	0.284	0.265	-0.110	0.199	0.191
	(0.168)	(0.111)**	(0.113)**	(0.162)	(0.110)*	(0.111)*
constant	3.025	4.833	4.697	2.548	4.363	4.342
	(0.523)***	(0.819)***	(0.585)***	(0.525)***	(0.590)***	(0.479)***
dms	0.102	0.141	0.172	0.115	0.160	0.177
	(0.056)*	(0.055)***	(0.061)***	(0.057)**	(0.052)***	(0.060)***
μ		3.087	3.038		2.860	2.839
		(0.730)***	(0.434)***		(0.518)***	(0.393)***
η			-0.006			-0.003

			(0.005)		(0.005)
Log likelihood	-101.389	-100.695		-105.951	-105.794
Prob > chi2		0.004	0.003	0.000	0.000

Notes:

(1)For each variable, the first line is the coefficient estimate, and the second line is the standard error.

(2)*, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 5: Results for Stochastic Frontier Analysis: r=price

	Model 7	Model 8	Model 9	Model 10	Model 11
Estimation Method	Fixed-Effects	TI	TVD	Fixed-effects	TI
lnK2	0.072	0.132	0.132	0.029	0.038
(r=price)	-0.066	(0.050)*	(0.048)*	-0.063	-0.027
lnL	-0.11	0.199	0.191	-0.213	0.23
	-0.162	(0.110)*	(0.111)*	-0.155	(0.113)**
constant	2.548	4.363	4.342	3.032	4.78
	(0.525)***	(0.590)***	(0.479)***	(0.471)***	(0.779)***
dms	0.115	0.16	0.177		
	(0.057)**	(0.052)***	(0.060)***		
μ		2.86	2.839		3.07
		(0.518)***	(0.393)***		(0.680)***
η			-0.003		
			-0.005		
Log likelihood		-105.951	-105.794		-104.664
Prob > chi2		0.000	0.000		0.041

Note: As for Table 5.

Table 6: Results for Measuring Efficiency via SFA model and VRS DEA model

r=usercost

		SFA			DEA (VRS)		
		TE	AE	PE	TE	AE	PE
Total	Mean	0.156	0.296	0.019	0.289	0.812	0.229
	Standard Deviation	0.011	0.028	0.000	0.018	0.013	0.015
With the DMS	Mean	0.108	0.364	0.018	0.435	0.775	0.335
	Standard Deviation	0.014	0.032	0.001	0.034	0.021	0.030
Without the DMS	Mean	0.182	0.258	0.020	0.208	0.833	0.171
	Standard Deviation	0.014	0.039	0.000	0.016	0.017	0.014

r=price

		SFA			DEA (VRS)		
		TE	AE	PE	TE	AE	PE
Total	Mean	0.152	0.388	0.022	0.306	0.820	0.241
	Standard Deviation	0.010	0.049	0.001	0.017	0.013	0.014
With the DMS	Mean	0.106	0.465	0.022	0.219	0.841	0.180
	Standard Deviation	0.013	0.037	0.001	0.023	0.019	0.019
Without the DMS	Mean	0.180	0.341	0.022	0.359	0.808	0.278
	Standard Deviation	0.014	0.075	0.001	0.023	0.018	0.019
Changes by the DMS		decrease	increase	remain	decrease	increase	decrease

Table 7: Skewness and Kurtosis of the Technical Efficiencies Estimated by SFA

	Skewness of u
r=usercost	4.339
r=price	3.696

6. Conclusion

There is a variety of anecdotal evidence from the managers of art related facilities concerning the various changes that occurred after introducing of the DMS, but it is too difficult to find any consistent results from this evidence. In order to assess the impact of the introduction of the DMS a random sample of roughly 20% of the population of public halls are used. The results of this analysis suggest that the introduction of the DMS did lead to an upward shift of the production frontier, but it did not lead to any major changes in the efficiency of production. To be specific, after the introduction of the DMS, Technical Efficiency decreased, Allocative Efficiency increased, and Productive Efficiency did not improved. As a result, it appears that the DMS has contributed to some facilities cutting costs. These results suggest that the DMS contributes to improving efficiency of firms that were already near the production frontier. The results also suggest that technical inefficiency is caused by the characteristics of the individual facilities. One possible reason for this is that only limited changes have been implemented carried out so far. Another possible reason is that the DMS does not work well on some facilities which are in the urban areas. While the DMS has improved the output of firms close to the production frontier, it has not contributed to reducing the inefficiency of inefficient public halls. It seems that an alternative system is needed to improve the efficiencies of these inefficient public halls.

APPENDIX

A. The Relationship between Public Financial Power and their Selection of the DMS

It has implied by Kobayashi (2002) that local governments with weak public financial positions would introduce the DMS to facilities under their control in order to reduce their fiscal deficits, but the analysis that follows suggests that actually the reverse has been observed, that is, local governments with strong public financial positions tend to have introduced the DMS.

Assume the following the following probit model:

$$\mathrm{DMS}_i^* = \alpha + \beta\ \mathrm{FINPOWER} + \mathrm{residual} \tag{A1}$$

$$\mathrm{DMS}_i = \begin{cases} 1 & \mathrm{DMS}_i^* > 0 \\ 0 & \mathrm{DMS}_i^* \leq 0 \end{cases}, \tag{A2}$$

where DMS_i^* is an unobserved latent variable; DMS_i is dummy variable for the i-th facility taking the value 1 if the i-th facility adopts the DMS and 0 otherwise; FINPOWER is a measure of the financial power of the local government that is related to the i-th facility; and ε_i is an error term that follows a standard normal distribution.

In order to estimate (A1) and (A2), cross-section data (2008) for on whether or not the DMS has been introduced for a particular facility is available from the Public Hall Data Base constructed by Japan Foundation for Regional Art-Activities in 2009; and data on FINPOWER comes from the "financial status of local governments" in Ministry Internal Affairs and Communications (Japan) (2008). The "financial status" of a local government is an indicator that shows what proportion of their necessary costs in a year can be self-financed. A ratio of less than unity indicates that the local government needs to issue bonds in order to meet the difference between its costs and its revenues. Figure 1 relates the proportion of halls that have introduced the DMS to the financial status of the local government involved.

When estimating (A1) and (A2), exactly the same 200 facilities used in the original panel dataset employed in Section 4 are used here. However, 20 facilities which have been established by prefectures are excluded from the analysis because the definition of "financial status" differs between prefectures, and cities. For the remaining 180 facilities, the mean financial status is 0.68, with a minimum value of

0.17 and a maximum value of 1.79 of these 180 facilities, had adopted the DMS.

The results of estimating equations (A1) and (A2) are:

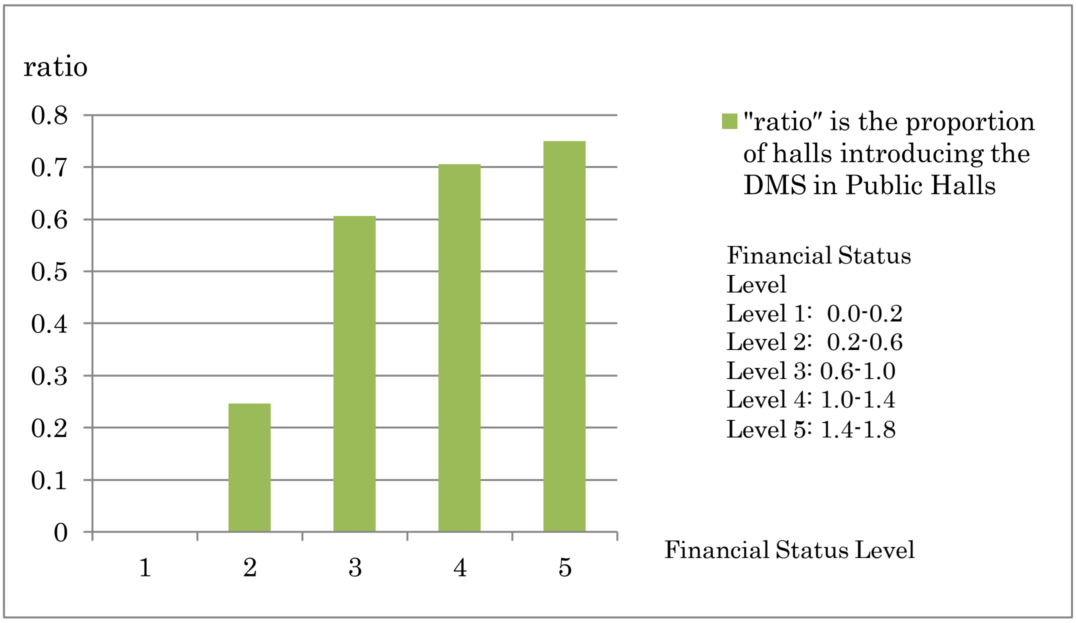
$$\text{DMS}^*(\text{DMS}=1) = -1.263 + 1.669\ \text{FINPOWER} + \text{residual}$$

$$(0.000^{***}) \quad (0.000^{***})$$

$$\text{N} = 180$$

where the values in brackets are p-values, and N is the sample size. The estimated coefficient of FINPOWER is positive and strongly significant suggesting that local governments with strong public financial positions have tended to introduce the DMS.

Figure 5: Proportion of Japanese Public Halls Introducing the DMS by Financial Status of Local Government Authority



B. Commands for Calculating Efficiency Indicators Using STATA

When a Cobb-Duglas production function is assumed, the three efficiency indicators are calculated in the following process, where 'q' is output, 'r' is price for capital, 'w' is wage, 'K' is the quantity of capital and 'L' is the quantity of labor.

1. Choose the appropriate model, from the time invariant model or the time-varying

decay model.

- xtfrontier lnY lnK lnL , ti
- xtfrontier lnY lnK lnL , tvd

2. Compute estimates of technical efficiency which calculated automatically by the Stata command.
   - predict u, te

3. Insert the estimated coefficients into the blanks.
   - gen b0=(   )   --------constant
   - gen b1= (   )   --------coefficient for lnK
   - gen b2= (   )   --------coefficient fot lnL

4. Estimate 'stochastic noise' as:
   - gen v=lnY-b0-b1*lnK-b2*lnL+u

$$\ln Y = \beta_0 + \beta_1 \ln K + \beta_2 \ln L + v - u$$

$$v = \ln Y - \beta_0 - \beta_1 \ln K - \beta_2 \ln L + u$$

5. Calculate the quantities of the technical efficient inputs.
   - gen s=k/l
   - gen Y=q
   - gen L_TE=(Y/((exp(b0 +v))*((s)^(b1))))^(-b1-b2)
   - gen K_TE=s*L_TE

$$K/L = S$$

$$K = SL$$

$$\ln Y = \beta_0 + \beta_1 \ln K + \beta_2 \ln L + v$$

$$\ln Y = \beta_0 + \beta_1 \ln SL + \beta_2 \ln L + v$$

$$\ln Y = \ln e^{\beta_0} + \ln (SL)^{\beta_1} + \ln L^{\beta_2} + \ln e^{v}$$

$$\ln Y = \ln\left\{\exp(\beta_0 + v)S^{\beta_1}L^{(\beta_1+\beta_2)}\right\}$$

$$Y = \exp(\beta_0 + v)S^{\beta_1}L^{(\beta_1+\beta_2)}$$

$$L^{TE} = \left\{Y/\exp\,(\beta_0 + v)S^{\beta_1}\right\}^{-(\beta_1+\beta_2)}$$

$$K^{TE} = S\left\{Y/\exp\,(\beta_0 + v)S^{\beta_1}\right\}^{-(\beta_1+\beta_2)}$$

6. Obtain the coefficients for the dual cost function.
   - gen delta_cons=(ln(b1+b2)-(b0 +ln(((b1)^(b1))*((b2)^(b2)))))/(b1+b2)
   - gen delta_K=(b1)/(b1+b2)
   - gen delta_L=(b2)/(b1+b2)
   - gen delta_Y=1/(b1+b2)

7. Calculate the productivity efficient total cost without stochastic noise, and then obtain the efficiency indicators.
   - gen lnC=delta_cons+delta_K*ln(r)+delta_L*ln(w)+delta_Y*(lnY-v)
   - gen C_A=exp(lnC)
   - gen K_PE =delta_K*((r)^(-1))* C_A
   - gen L_PE=delta_L*((w)^(-1))*C_A
   - gen TE=(r* K_TE+w*L_TE)/(r*k+w*l)
   - gen AE=(r*K_PE+w*L_PE)/ (r*K_TE+w*L_TE)
   - gen PE=(r*K_PE+w*L_PE)/(r*k+w*l)

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