Essays on Some Impacts of Deregulation in Japan: Methods and Applications using Frontier Functions

by

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Abstract

This thesis analyzes the impact of deregulation of the public sector and the regulated private sector. The particular deregulation that is analyzed was intended to reduce inefficiencies by introducing competition and promoting new entry. The main purpose of this thesis is to provide a useful methodological framework to measure the impacts of new entry on the efficiency of the public sector in Japan using frontier functions and to provide some empirical illustrations of this framework. Part I (Chapters 2 and 3) discusses the impacts of a particular type of privatization of public facilities, the Designated Manager System (DMS), which was intended to introduce market mechanisms into the public sector. In this Part, the impacts on the introduction around 2006 of the DMS for public halls are investigated. Chapter 2 measures how the productive efficiency of Japanese public halls has changed following the introduction of the DMS. Chapter 3 attempts to examine whether public cultural policies to expand the demand for art and culture has succeeded in increasing the demand for private music concerts in Japan. In particular, this chapter focuses on how the introduction of the DMS for public halls increased the demand for private music concerts. A feature of this chapter is to capture some of the impacts of each local government's cultural policy to expand the demand for art and culture. This chapter theoretically represents how to measure the different impacts of cultural policy by each local governments, using the frontier function. In Part II (Chapter 4), the impacts of deregulation in a monopoly market, the electricity market, are discussed. In particular, the changes in cost efficiencies associated with the liberalization of the electricity markets are examined. Chapter 4 measures the improvement in cost efficiencies caused by higher degrees of the electricity liberalization. Finally, Chapter 5 contains some concluding remarks that are

derived from the preceding chapters, focusing on the relevant methodologies and policy implications. Some of the potential areas for further research are also discussed.

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Chapter 1

Introduction

Since 1930s, it has been pointed that less competitive situation often leads to inefficient economic performance. Hicks (1935) observed that monopolistic firms were less close to the position of maximum profit and suggested the possibility that competitive pressure might improve inefficiencies of firms. Similarly, Alchian (1965) insists that public production is originally less efficient than private production and that the competitions with private owner give public owner the incentive to diminish production cost. Niskanen (1971), de Alessi (1974), and Lindsay (1976) also argued that the absence of competitive pressure lead to inefficient management in public sector. Hansmman (1988) and Holmstrom and Tirole (1989) investigated that different owner ship forms generated different performances of managements than just private or public.

In order to reduce or eliminate the inefficiencies of the managers who supply public or quasi-public goods in less competitive situations, the introduction of competition by deregulation is sometimes applied to both public sector and private sector. Most market regulations were related to supplier behavior. Therefore, it can be thought that deregulation first influences the supplier, and then the impact of deregulation influences consumer through changes in suppliers' behavior.

Frontier analysis can be used to examine whether a more competitive situation has reduced inefficiency. The characteristic of frontier analysis is that the difference between the empirical estimates of efficient performances and the actual inefficient performances can be used as a measure of the inefficiency of economic performances. In frontier analysis, a set of efficient performances¹ are estimated as a frontier and the distances between the frontier and actual observations are estimates of inefficiencies. Figure 1-1 shows how we can define a frontier and inefficiency in the case of a production function with one output, Y, produced two inputs, X₁ and X₂. In this Figure, L(Y) denotes the set of all possible combination of X₁ and X₂ that lead to Y being produced. In Figure 1-1, X^A, X^B, and X^C denote efficient observations, and the set of the efficient observations can be defined as the production frontier I(Y) in this production. On the other hand, X^D denotes an inefficient observation, and the difference between X^A which has the same rate of X₁ and X₂ as X^D and X^D can be defined as an inefficiency. Debreu (1951) and Farrel (1957) define this input-orientated inefficiency as the technical efficiency and measure as follows:

$$TE(Y, X) = \min\{\theta: \theta X \in L(Y)\},$$
(3)

where TE(Y,X) is technical efficiency, and X is the vector of input.

 $^{^{1}}$ In frontier analysis, statements are made relative to the frontier, but it is possible that the estimated frontier does not indicate the most efficient situation if the most efficient agent in the sample itself is operating inefficienciently.



Figure 1-1: Definition of Production Frontier and Inefficiency

When frontier models are compared to the usual panel models, frontier models have the merit that it is possible to allow for variation in the distributions of the inefficiencies assumed. For example, a fixed-effects frontier model can assume that the production performances are different between the decision-making units, and that the production performance of every decision-making unit improves as time passes, while a standard fixed-effects model allows frontier for not time varying differences in the production performances between decision-making units. On the other hand, frontier models have the demerit that robustness checks and the choice of the best frontier model by hypothesis testing is empirically more difficult than for non-frontier models.

Parametric, semi-parametric, and non-parametric approaches are empirically used for frontier analysis. 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. SFA was developed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) in the economics area, while DEA was 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.

In many economic analyses, the impacts of deregulation policies are measured using a frontier function, for example, Sakai and Takahashi (2013), Seim and Waldfogel (2013), and Lee (2010). In Japan, since the bubble burst in the early 1990s, inefficiencies in the public sector have been a hot topic of discussion. To try to reduce these inefficiencies in the public sector, the Japanese government has carried out various reforms. Using frontier analysis, this thesis analyzes some impacts of deregulations which have been implemented in Japan since 1990.

The main purpose of this thesis is to provide a useful methodological framework to measure the impacts of new entry on the efficiency of the public sector and the regulated private sector using frontier functions and to provide some empirical illustrations of this framework. Related to this purpose, the present thesis contains a discussion of some methodological issues related to frontier analysis and its applications. Part I (Chapters 2 and 3) discusses the impacts of a particular type of privatization of public halls, the Designated Manager System (DMS), which was intended to introduce market mechanisms into the public sector. In this part, the impacts of the introduction around 2006 of the DMS for public halls on the supply and demand sides are investigated. Chapter 2 measures how the productive efficiency of Japanese public halls has changed following the introduction of the DMS. Chapter 3 attempts to examine the effect of the introduction of the DMS on the demand for private music concerts in Japan. In particular, this chapter focuses on how the introduction of the DMS for public halls might have influenced the demand for private music concerts. Definitely, one task of public halls is to expand the demand for art and culture. Thus, Chapter 3 attempts to capture the differences of the impact of local governments' cultural policies via a frontier function. In Part II (Chapter 4), the impacts of deregulation in a monopoly market for energy production and distribution are discussed. In particular, the changes in cost efficiencies associated with the liberalization of electricity markets are examined. Chapter 4 measures the changes in cost efficiencies caused by different degrees of the electricity liberalization. Finally, Chapter 5 contains some concluding remarks that are derived from the preceding chapters, focusing on the relevant methodologies and policy implications. Some of the potential areas for further research are also discussed.

A brief summary of each chapter and its contribution follows. Chapter 2 measures how the productive efficiency of Japanese public halls has changed following the introduction of the DMS. The DMS which was introduced for public halls around 2006 was intended to introduce market mechanisms into the public sector. In particular, Chapter 2 hypothesizes that the DMS 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 have shifted toward more efficient posiition, and production inefficiencies are expected to be smaller as a result of the introduction of the DMS. An unbalanced panel data set from 2004 to 2009 on 200 randomly chosen public halls, roughly 10% of the total number of public halls in Japan, was constructed by the author. A stochastic production frontier is estimated to measure the impact of the introduction of the DMS on the productive efficiency. It is found that the introduction of the DMS has increased the productivities in frontier, but it did not lead to any large change in the efficiency of production.

The empirical findings in Chapter 3 suggest that public cultural policy has a significant impact in increasing the sales of tickets for private music concerts. In particular, this chapter focuses on how the introduction of the Designated Manager System (DMS) in 2006 influenced the sales of tickets for private music concerts. The hypotheses that both the local governments' cultural expenditure and the introduction of the DMS increased the sales of tickets for private music concerts are examined. Data from the Private Music Live Entertainment 2000-2008 is used to investigate the factors which influence the sales of tickets for private music concerts. The estimation results suggest that the DMS has improved the local governments' cultural policies to increase ticket sales for music concerts.

The objective of Chapter 4 is to measure the impact of liberalization on the efficiency of electricity production, and to examine whether or not economies of scope exist between electricity generation and transmission. Since 1995, liberalization of the electricity market in Japan has been phased in and regulations on entry have been relaxed three times. One motivation for these regulatory changes has been to improve the efficiency of electricity production by introducing competition. Using a panel data set on the nine main power companies in Japan over the period 1970-2010, estimates of the power companies' cost functions using fixed-effects models and stochastic frontier models are obtained and compared. As a result of this comparison, a fixed-effects model is found to better than stochastic frontier model in explaining power companies' costs. Estimates of the cost function show that liberalization has improved cost efficiency. Economies of scope are also found to exist for all power companies on average.

Finally, Chapter 5 contains some concluding remarks that are derived from the preceding chapters, focusing on the relevant methodologies and policy implications. Some of the potential areas for further research are also discussed by observing the relevant methodological and policy implications derived from the preceding chapters. Further, the potential directions for further research in the analysis of deregulation are discussed, with a focus on econometric analysis using frontier analysis.

PART I.

The Privatization of Public Facilities: Public Halls

Chapter 2

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

2.1 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 How*), "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 Since 2000, the construction of public halls has inefficiency in the public sector. continued, and there are now about 2200 facilities in total.

This chapter aims to assess the economic effect of the introduction of the DMS on Japanese public halls by estimating an efficiency indicator. There are two areas of existing research that are related to this chapter: general assessments of the management of public facilities; research related to the DMS system.

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 and/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 public 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.

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 chapter 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 chapter is organized as follows. Section 2.2 presents the background relating to why the DMS was introduced for public halls in Japan. In this

section, Section 2.3 provides an explanation of the methodology used to measure inefficiencies. Section 2.4 gives detail of the data used in this chapter. Section 2.5 presents the empirical results. Section 2.6 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.

2.2 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 The EMS has a less characteristic of the New Public of the local government. 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 2-1 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 2-1, 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.

| | Percentage of | Manag | er Type |
|--|---------------|--------|------------|
| | Facilities | | |
| | Adopting | Public | Non-public |
| | DMS | | |
| Prefectural facilities | 68.9% | 65% | 35% |
| Facilities of Cities Designated by | 70.99/ | C10/ | 200/ |
| Ordinance | 19.270 | 0170 | 3970 |
| Facilities of Municipalities except Cities | 28 204 | 970/ | 790/ |
| Designated by Ordinance | 28.2% | 2190 | 13% |
| Total | 34.2% | 37% | 63% |

Table 2-1: Adoption of Designated Manager System by Public Facilities for the Arts and Culture (includes not only public halls but also other public cultural facilities)

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)

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.

2.3 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).

2.3.1 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 2-1 and 2-2 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:

$$TE \equiv OX^B / OX^A \tag{1}$$

$$AE \equiv OX^{C}/OX^{B}$$
⁽²⁾

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



Figure 2-1: Definition of Inefficiency Indicators via SFA





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

2.3.2 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:

$$\ln y_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k \ln x_{kit} + v_{it} - u_{it}$$
(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 $\sigma_u^2=0$, all public halls are efficient producers.

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

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

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

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:

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

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

$$\delta_{k} = \beta_{k} / \sum_{k=1}^{K} \beta_{k} \quad , \tag{9}$$

$$\delta_{\rm y} = 1/\sum_{\rm k=1}^{\rm K} \beta_{\rm k} \quad , \tag{10}$$

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.

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

where x_{kit}^{E} 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:

$$TE_{it}^{SFA} = \sum_{k=1}^{K} w_{kit} x_{kit}^{T} / \sum_{k=1}^{K} w_{kit} x_{kit} , \qquad (12)$$

$$AE_{it}^{SFA} = \sum_{k=1}^{K} w_{kit} x_{kit}^{E} / \sum_{k=1}^{K} w_{kit} x_{kit}^{T} , \qquad (13)$$

$$PE_{it}^{SFA} = \sum_{k=1}^{K} w_{kit} x_{kit}^{E} / \sum_{k=1}^{K} w_{kit} x_{kit} \quad .$$
(14)

2.3.3 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 chapter.

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

 $\min \theta (= TE_i^{DEA})$ s.t. $-y_{it} + Y\lambda \ge 0$ $\theta x_{it} - X\lambda \ge 0$ $e1'\lambda = 1$ $\lambda \ge 0, \qquad (15)$

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. $-y_{it} + Y\lambda \ge 0$ $x_{it}^{E} - X\lambda \ge 0$ $e1'\lambda = 1$ $\lambda \ge 0$ (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:

$$PE_i^{DEA} = w_{it}' x_{it}^E / w_{it}' x_{it} , \qquad (17)$$

$$AE_{it}^{DEA} = PE_{it}^{DEA} / TE_{it}^{DEA}.$$
 (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.

2.3.4 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

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

TVD Model

$$\ln Q_{it} = \alpha \ln K_{it} + \beta \ln L_{it} + \gamma + \delta dm s_{it} - u_{it} + v_{it}, \quad u_{it} = \exp\{-\eta(t - T_i)\}u_i$$
$$u_i \sim N^+(\mu, \sigma_{\mu}^2), \quad v_{it} \sim N(0, \sigma_{\nu}^2), \quad (20)$$

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 chisquare 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).

2.4 Data

The data used in this chapter 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

$$UC = i + D - \dot{P}/P , \qquad (24)$$

where UC is the usercost, **i** is the interest rate for loan payments, **D** is the rate of depreciation, and \dot{P}/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 3-2 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. The number of capital, K is calculated by K = (the total number of labor wages)/(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 chapter. 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 chapter, 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. The survey results of Research Institute of Industry and Regional Economy (2006) shows that 60.9 % of public halls used no volunteers in 2007. Certainly 21.6 % of public halls used volunteers constantly. However Figure 2-3 shows the main tasks of volunteers are as receptionists, ushers, or the staff in halls. 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.

| 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 | |
| \mathbf{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 | |

Table 2-2: Descriptive Statistics

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 | |
| \mathbf{L} | 14.026 | 17.565 | 11.90625 | |
| r2 | 93.774 | 93.797 | 93.640 | |
| K2 | 766.955 | 16.796 | 752.800 | |
| \mathbf{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.


Figure 2-3: The Kinds of the Works for the Regular Volunteers

The total sample size is 262.

Source: as for Table 1

2.5 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,

Tables 2-3 and 2-4 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.

The results for the parametric models in Tables 2-3 and 2-4 indicate that all the estimated coefficients associated with the two inputs are positive, except the coefficients in the fixed effect model. 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. In other word, 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. 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. 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 2-5. 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. 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 2-5 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.

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|----------------------|---------------|------------|------------|---------------|------------|------------|
| Estimation Method | Fixed-Effects | TI | TVD | Fixed-effects | TI | TVD |
| lnK1 | -0.008 | 0.021 | 0.028 | | | |
| (r=usercost) | (0.029) | (0.028)* | (0.028)* | | | |
| lnK2 | | | | 0.072 | 0.132 | 0.132 |
| (r=price) | | | | (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 |
| η | | (0.730)*** | (0.434)*** | | (0.518)*** | (0.393)*** |
| - | | | -0.006 | | | -0.003 |
| T 1-1 1-1 1 | 101.000 | 100.00 | (0.005) | | 105 051 | (0.005) |
| Log likelihood | -101.389 | -100.695 | | | -105.951 | -105.794 |
| Prob > chi2 | | 0.004 | 0.003 | | 0.000 | 0.000 |

Table 2-3: Results for Stochastic Frontier Analysis

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.

| | Model 7 | Model 8 | Model 9 | Model 10 | Model 11 |
|----------------------|---------------|------------|------------|---------------|------------|
| Estimation Method | Fixed-Effects | TI | TVD | Fixed-effects | TI |
| lnK1 | 0.002 | 0.107 | 0.038 | | |
| (r=usercost) | (0.029) | (0.051)** | (0.029) | | |
| lnK2 | | | | 0.029 | 0.038 |
| (r=price) | | | | (-0.063) | (-0.027) |
| lnL | -0.230 | 0.168 | 0.232 | -0.213 | 0.23 |
| | (0.161) | (0.114) | (0.117)** | (-0.155) | (0.113)** |
| constant | 3.149 | 4.687 | 4.790 | 3.032 | 4.78 |
| | (0.5229*** | (0.631)*** | (0.849)*** | (0.471)*** | (0.779)*** |
| dms | | | | | |
| | | | | | |
| μ | | 2.931 | 3.077 | | 3.07 |
| | | (0.556)*** | (0.749)*** | | (0.680)*** |
| η | | | 0.000 | | |
| | | | (0.004) | | |
| Log likelihood | | -110.575 | -104.662 | | -104.664 |
| Prob > chi2 | | 0.013 | 0.041 | | 0.041 |

Table 2-4: Results for Stochastic Frontier Analysis

Note: As for Table 5.

| r=price | | | | | | | |
|--------------------|--------------------|----------|----------|--------|----------|----------|----------|
| | | SFA | | | DEA (V | RS) | |
| | | 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 | Mean | 0.106 | 0.465 | 0.022 | 0.219 | 0.841 | 0.180 |
| the DMS | Standard Deviation | 0.013 | 0.037 | 0.001 | 0.023 | 0.019 | 0.019 |
| Without | Mean | 0.180 | 0.341 | 0.022 | 0.359 | 0.808 | 0.278 |
| the DMS | 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 2-5: Results for Measuring Efficiency via SFA model and VRS DEA model

2.6 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

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:

$$DMS_{i}^{*} = \alpha + \beta FINPOWER + residual$$
(A1)

$$\mathsf{DMS}_{i} = \begin{cases} 1 \ \mathsf{DMS}_{i}^{*} > 0\\ 0 \ \mathsf{DMS}_{i}^{*} \le 0 \end{cases}$$
(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 A-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 2.4 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:

DMS*(DMS = 1) = -1.263 + 1.669 FINPOWER + residual (0.000***) (0.000***) 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 A-1: Proportion of Japanese Public Halls Introducing the DMS by Financial Status of Local Government Authority

Chapter 3

The Impact of Local Government Cultural Policies on the Sales of Tickets for Private Music Concerts in Japan²

3.1 Introduction

As a result of the cultural policy in the 1990s, over 2200 public halls have been constructed all over in Japan and the huge cost of maintaining these halls have become a heavy burden for local governments. The 1990s' cultural policy which invested in cultural facilities fairly all over Japan has been reexamined since the promulgation of a law for promoting art and culture (*Bunka Geijutsu Shinkou Hou*) in 2001. Recently, in Japan, a movement to enact a law for public halls (*Gekijo Hou*) has gained momentum. Based on these recent circumstances, it has been argued that public hall hubs should be established in Japan and public investments be made in them. In order to address this issue, it is necessary to assess the effect of the recent public investments in public halls.

Both the effectiveness of investments in public halls and the appropriate roles of the public sector and private sector have become recent policy issues. In 2006, the Designated Manager System (DMS) was introduced to public halls as a part of the *Koizumi* Government's structural reforms. Generally, it was considered that there was a lot of wasteful expenditure associated with Japanese public halls, so it was rather

² Chapter 3 has published in *Keio Economic Studies*.

natural that the DMS was applied to public halls. One of the main purposes of the DMS was to reduce the public sector's role so the private sector could play a greater role. Around the time of the introduction of the DMS, the privatization of the managers of public halls also became an issue, and the appropriate roles of the public sector and private sector and the interactions between them were discussed intensively.

However, there are very few studies measuring the effect of these public policies in Japan. This chapter aims to examine the impact of the local governments' cultural policy related to public halls on the private sector especially the consumption of live private music entertainment. According to the *PIA* Institute, live music entertainment refers to all music concerts except drama or musicals, for example, popular music (excluding musicals), classical music, *enka* ballads, and jazz are all treated as music concerts. To be concrete, this chapter examines the impact and crowding-out effects of the DMS on the consumption of live private music entertainment using econometric methods.

The existing research related to this chapter can be classified into the following two broad groups: econometric studies and sociological studies. Econometric studies are mainly related to the estimation of demand functions and the estimation of stochastic frontier models. There are many studies estimating demand functions, but here the focus is on studies related to "cultural" goods. Arima (2006a, 2006b, 2008, 2010, and 2011) estimates demand functions for activities related to art and culture in Japan using micro data constructed by the Japanese government. Arima's analysis is an age period cohort analysis. Zieba (2009) estimates a demand function for German public theaters to examine the income and price elasticities of demand. Zieba (2011) examines the determinants of the demand for theatre tickets in Austria and Switzerland. However, the aims of these studies are not to examine the impact of cultural policies. The existing papers which examined the existence of crowding-out mainly investigate the impact of public policy on private grants in the U.S. For example, Dokko (2009) examines whether or not the federal government's funding of the arts through the National Endowment for the Arts crowds out private charitable contributions to the arts in the U.S. Schmitz (2010) examines whether or not the system crowds out private foundations in the U.S.

Recently, some studies estimate a demand function and measure inefficiencies using a stochastic frontier approach. For example, Fillipini and Hunt (2009, 2011) estimate a demand frontier for aggregate energy incorporating an inefficiency approach. In this case, using different vintages of consumer goods or consumer goods with different levels of embodied technology will lead to different energy uses. With all other things equal, the agent with the lowest energy use is the most efficient energy user, and all other uses can be deemed to be inefficient.

Some empirical studies estimate stochastic frontier models for music halls. Taniguchi (2011) measures the technical, allocative, and productive efficiency of Japanese public halls via stochastic frontier analysis and data envelop analysis. Last and Wetzel (2010) estimate the efficiency of German public theaters using four models: a fixed-effects model, a random-effects stochastic frontier model, a true random-effects stochastic frontier model, and a true random-effects with a Mundlak formulation. However, these studies analyze the supply side not the demand side.

Most studies of the DMS are sociological studies that tend to discuss the DMS system from an ideological perspective. Nakaya (2005) summarizes the situation facing public halls before the DMS was introduced, and points to the importance of assessing the work of designated managers after the DMS was introduced. Nakaya (2005) has become a kind of handbook for local governments and art managers. From the view point of political sociology, Kobayashi (2006) points out the difficulties in assessing the activities in the cultural sector and considers the problems that might arise after the introduction of the DMS. Cultural Policy Network edi. (2004) estimates 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 expresses a negative opinion concerning economic assessments of public facilities via economic indicators because she thinks that the public facilities for art and culture have some value which is not measurable by economic indicators. Nakagawa and Matsumoto (2007) also express 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. However, some recent studies assess or discuss the impact of the DMS on the performance of designated managers of public halls during their initial contract term. Taniguchi (2011) measures the impacts of the DMS on the technical, allocative, and productive efficiencies of public halls, via Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). Her study concludes that the impact of the DMS on productive efficiency is not clear for the first contract term. Taniguchi (2011) analyses the impact of the DMS on the supply side, but the impact of the DMS on the demand side is not analyzed.

The key contributions of this chapter are: verifying the hypothesis that local governments' cultural expenditure leads to a crowding out of the demand for private sector concerts; and estimating a reduced form equation for the number of ticket sales for private music concerts in Japan. This is the first application of Stochastic Frontier Analysis (SFA) to demand functions for art and culture related activities in Japan.

The rest of this chapter is organized as follows. Section 3.2 summarizes the local governments' cultural policies in Japan. Section 3.3 discusses the relationship between the local governments' cultural policies and the consumption of live private music entertainment in Japan. Section 3.4 details the models to be estimated and their interpretation. Section 3.5 gives details of the data used in this study. Section 3.6 presents the empirical results, and Section 3.7 contains some brief concluding remarks.

3.2 Consumption of Live Private Music Entertainment and the Local Governments' Policy in Japan

This section explains the relationship between private concert suppliers and the public sector to show how cultural policy can potentially affect the demand and the supply of private concerts. Then, the potential impact of the DMS on the private sector is considered.

Recently, local governments' cultural investments are mainly used for the maintenance and upkeep of existing cultural facilities and for undertaking cultural events. This study focuses on the latter. By the way, Nakagawa (2004) categorizes local governments' cultural policies in Japan into 4 groups; cultural policies to spread art and culture, based on the idea that the public sector should distribute art and culture to all inhabitants as a social welfare policy; cultural policies to activate local economies; cultural policies to build up an identity for a community, using the identical art and culture as one resource; and cultural policies to disturb the existing order and to introduce new discoveries or new value added into communities (pp. 94 - 98, ll. 5 - 7).

Nakagawa (2004) gives concerts at public halls produced by local governments as a typical example of the first category and criticizes local governments that only in most of cases buy packaged concerts. The point of Nakagawa (2004) is that most Japanese local governments have not made efforts to provide effective concerts to increase the demand for art and culture. One aim of the introduction of the Designated Manager System (DMS) in 2006 was to reduce the inefficiency in local governments' cultural investments.

Now, the possible impacts of the DMS on the demand side are discussed in detail. Not only public art managers, but also private art managers use public halls in Japan. Most live music entertainment is planned by private art managers or artists who do not own their own hall. In Japan, most live music entertainment is supplied by combining the "hardware" of the public sector and the "software" of the private sector. Therefore, a change in the public policy related to public halls has the possibility of having an effect on the private sector. In order to realize a balanced supply between the private and public sectors, it is important to analyze the effects of public policy on the private sector's consumption of private music concerts.

The DMS was introduced to public halls in 2006 to enable private art managers to manage public halls. Local governments can choose whether they introduce the DMS into the public halls which the local governments established. 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 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. According to the minutes of the General Affairs Committee of the House of Representatives (*Shugiin Soumu Iinkai*), the purpose of the introduction of the DMS is to supply public services which are more suitable to needs of local residents (Kobayashi (2006), p. 4, ll. 16 - 18). According to a survey by Association of Public Theaters and Halls in Japan (2009), the percentage of public halls that had introduced the DMS was 40.2% in 2006, and this increased to 47.6% in 2009. Now, about 50% public halls have introduced the DMS. The introduction of the DMS made the managers of public halls more cost conscious. One evidence which supports this is that the proportion of public halls charging some sort of piece of user fee has increased, and 69% of halls charged some sort of user fee in 2009 (Association of Public Theaters and Halls in Japan (2009)).

Both positive and negative impacts of the DMS on the demand for private music concerts are possible, and these effects are explained in the following. One positive effect of the DMS on the private sector is that the private marketing of public events to popularize music may lead to an increase in the consumption of private music concerts; this positive effect leads to the upward shift of demand function. Some public concerts are produced to increase the total demand for music concerts. Figure 3-1 shows that public halls supply 9.9 concert events per year on average. The number of public music concerts is not so large, compared to the number of private music concerts. Nonprofitable concerts are mainly supplied by the public sector, and these make up about 40 % of all public concerts including both classical music and popular music.



Figure 3-1: The Numbers of Events and Performances in Public Halls in a year



According to a survey by the Association of Public Theaters and Halls in Japan (2009), about 45% of the classical music concerts were non-profitable, and 40% of the popular music concerts and the other concerts were non-profitable in 2009. These nonprofitable concerts will have no effect on the demand for private concerts unless an audience turns up. Even if an audience does turn up and the participants are all "new," then there may still be no effect on the demand for private concerts.

Another possible positive effect of the DMS is to decrease the ticket prices for private concerts through price competition. Then, lower ticket price will increase the demand for private concerts as long as the private managers try to keep the quantities of supply for private music concerts; this positive effect may lead to the shift of demand function by the shift of supply curve. The consumers who have the lower income could enjoy private music concerts more often. To increase the audience, the DMS has the possibility of lowering the prices of the concerts which are managed by DMS institutions. If the ticket prices for private music concerts are reduced, the audiences of private music concerts expand to include some consumers who have lower income.

Alternatively, if as a result of the introduction of the DMS system, people turn up to public concerts and they are drawn away from private concerts rather than being new participants, then there will be a negative effect on private concerts. This negative effect is possible when public concerts and private concerts are substitutes. Generally, it assumed that the public sector will try to provide music concerts to complement private music concerts, so that public cultural expenditure will not lead to any crowding-out effects. However, if public concerts are privatized as a result of the introduction of the DMS, the possibility of crowding-out effects cannot be denied. Another possible negative effect is that an increase in the cost of concerts may result from the introduction of the public system charging the private sector for the use of public halls. This negative effect has not occurred yet since the DMS was introduced. Figure 3-2 shows that the average ticket price has decreased since 2006. For this reason, this negative effect is not considered in this analysis.

Figure 3-2: Average Ticket Price



Source: Constructed using data in the Private Music Live Entertainment (2008). Note:

This average price is the estimated average price of the concert tickets (= sales / attendance), where "Sales" includes not only the sales of the concert tickets, but also concert-related goods like CDs.

Considering the circumstances mentioned above, it is assumed that the positive effects of the DMS are stronger than negative effect. Econometric methods will be used to verify whether or not this is the case.

3.3 Three Channels where Cultural Policies Have

Influences on Demand

This section explains how the DMS may lead to the increase of the demand for private music concerts; one effect is the development of potential audiences by new marketing; another effect is caused by lower ticket prices. In this section, the channels where the DMS affects the demand for private music concerts are discussed theoretically. Then it will be clear that the different effects of the DMS and cultural expenditures among the local governments can be observed on both the supply side and demand side. In other words, this chapter attempts to measure the impacts of the supply side on the demand side, which are different among local governments, where perfect competition between the public and private sectors are assumed.

There are three channels through which local governments' cultural policies influence the demand for music concerts. First, Figure 3-3 shows where the DMS and cultural expenditures shift the demand function upward. The DMS and the public cultural expenditures would shift the demand function upward from DD to D'D' directly (Figure 4) because some public music concerts are intended to expand the number of consumers of music concerts as a cultural policy. The former positive effect of the DMS in section 3.2 is categorized in this channel. This increase of demand is defined as a crowding-in effect in this study. There might be some differences in the crowding-in effects among 47 local governments' cultural policies, because the content of the cultural policies differs among the 47 local governments. This study attempts to capture the differences of the impacts of cultural policies on the demand for private music concerts as an inefficiency term.

Figure 3-3: The Crowding-in Effects of Local Governments' Cultural Policy I



Secondly, Figure 3-4 shows the mechanisms through which the local governments' cultural policies lead to crowding-in effects indirectly via a shift in the supply curve. The latter positive effect in Section 3.2 is categorized in this channel. Assume that the local governments invest in the promotion of culture and then public music concerts are supplied at prices that are lower than the prices for private music concerts. Then supply curve shifts from S_1S_1 to $S_1'S_1'$. In order to prevent customers switching to public concerts, private music suppliers will respond to the lower ticket prices of public concerts by decreasing the ticket prices for private music concerts. Then the supply curve for private music concerts shifts from S_2S_2 to $S_2'S_2'$. The distance between S_2S_2 and $S_2'S_2'$ is defined as the inefficiency which can improve by the cultural policy. This movement along the demand curve results in a shift of the equilibrium point from E_2 to E_2' . This increase of demand is also defined as crowding-in effects. Here, it is assumed that the public music concerts which are the substitutes for private music concerts lead to this effect.

Figure 3-4: The Crowding-in Effects by Local Governments' Cultural Policy II



Thirdly, on the other hand, Figure 3-5 shows the mechanism of no effects in the sales of tickets for private music concerts by neither the DMS nor the cultural expenditure. Assume that the local governments invest in the promotion of culture and then public music concerts are supplied at the prices (P') that are lower than the prices of private music concerts (P). In the case of perfectly inelastic demand in the market for public music concerts, the ticket price would be lower (P>P') while the demand for private music concerts would remain at X*. Thus, a lower ticket price for public concerts does not lead to any increase in the sales of tickets for private music concert in the case of perfectly price inelastic demand for private concerts.

While third channel cannot be examined directly by checking any estimated coefficients, the existence of crowding-in effects via the first channel or via the second channel can be examined by the checking the coefficient of the DMS dummy, and by the checking whether the coefficient of the local governments' cultural investment is positive or not in supply function.

Figure 3-5: The Crowding-out Effects by Local Governments' Cultural Policy



3.4 Method

3.4.1 A Definition of Inefficiency of Cultural Policies

Generally, the efficiency concept is used to measure the inefficiency of production when either a production function or a cost function is estimated. However, some existing studies have applied the efficiency concept to the estimation of demand functions. The first applications of the inefficiency concept to an analysis of the demand side are Fillipini and Hunt (2009, 2011). These studies estimated a "demand frontier" for aggregate energy using a panel data set on 29 countries over a 28 year period from 1978 to 2006. Fillipini and Hunt's (2009, 2011) analysis indicates that inefficiencies in energy demand (higher energy demand than otherwise would be the case) are caused by the use of outdated technologies or machines which are associated with higher electricity consumption compared to newer technologies or machines.

In Fillipini and Hunt (2009, 2011), all the standard factors which influence energy demand are used as explanatory variables in the aggregate demand for energy, so that inefficiencies of energy demand are measured as the unobservable effect of using outdated technologies or machines. Thus, Fillipini and Hunt (2009, 2011) indicate that it is possible to apply the concept of inefficiency to an analysis of consumer demand.

In this study, the differences in the position of the demand functions among 47 prefectures during the estimation period are treated as being caused by inefficiencies of demand. In Figure 3, a more efficient cultural policy would cause a large upward shift in the demand function. This may be observed as the difference in the inefficiency terms in a stochastic frontier model.

3.4.2 The Estimated Model

As discussed in Section 3.4.1, the difference of the impact of local governments' cultural policies may be observed in the demand function as an inefficiency term. Then, the aggregate demand function for private music concerts can be written as follows:

$$\ln Q_{it} = a \ln P_{it} + \sum_{r=1}^{m} b_r \ln E_{it_r} + c + w_{it} + \varepsilon_{1it}, \qquad (1)$$

where Q_{it} is the total number of people attending private concerts in the i-th prefecture in year t, P_{it} is the average price of the private concerts in the i-th prefecture in year t, E_{it_r} are the other factors which influence the demand in the i-th prefecture in year t, w_{it} is a measure of technical inefficiency, ε_{1it} is disturbance that is assumed to follow a normal distribution, and a, b_r , and c are coefficients.

The aggregate supply function for private music concerts can be written as follows:

$$\ln Q_{it} = d \ln P_{it} + \sum_{r=m}^{n} f_r \ln E_{it_r} + g + h dms_{it} + z_{it} + \varepsilon_{2it}, \quad (n > m)$$
(2)

where dms_{it} is the ratio of the number of public halls in the i-th prefecture at time t that have introduced the DMS to the total number of public halls in that prefecture, z_{it} is a measure of technical inefficiency, ε_{2it} is disturbance that is assumed to follow a normal distribution, and d, f_r , g, and h are coefficients. Given the definition of dms_{it} , its value obviously lies between zero and one. It is worth noting that the DMS is assumed to directly affect only the supply of music concerts and not their demand.

Therefore, the estimated reduced equation for the number of people attending private concerts can be obtained from equations (1) and (2) as follows:

$$\ln Q_{it} = \sum_{r=1}^{n} \beta_r \ln E_{it_r} + \gamma + \delta dm s_{it} + e_{it_r},$$

$$e_{it} = \frac{a(z_{it} + \varepsilon_{1it}) - d(w_{it} + \varepsilon_{2it})}{a - d} = \left(\frac{a}{a - d} z_{it} - \frac{d}{a - d} w_{it}\right) + \left(\frac{a}{a - d} \varepsilon_{1it} - \frac{d}{a - d} \varepsilon_{2it}\right) \equiv u_{it} + v_{it}, \quad (3)$$

where $\beta_{\rm r}$, γ , and δ are coefficients. In equation (1) and (2), it is assumed that $w_{\rm it}$, $z_{\rm it}$, and $e_{\rm it}$ have identical distributions. Since "a" is the coefficient of the own price in a demand function, it is expected that a < 0. Because "d" is the coefficient of the own price in a supply function, it is expected that d > 0. Therefore, both $\frac{a}{a-d}$ and $-\frac{d}{a-d}$ are positive. Both $z_{\rm it}$ and $w_{\rm it}$ are assumed to take on only non-positive values because they measure technical efficiency. For these reasons, $\left(\frac{a}{a-d}z_{\rm it} - \frac{d}{a-d}w_{\rm it}\right) = u_{\rm it}$ is always negative. The discussion of the possible assumptions for the distribution of $u_{\rm it}$ is contained in the next paragraph.

The variables will be included in $\ln E_{it_r}$ are the total number of the private music concerts per capita, per capita income, the financial power of a prefecture, and local governments' cultural expenditure on events and education. Because the consumers can match their schedules more easily, it is considered that considered that the total number of concerts per capita increases the demand for private music concerts. The higher consumers income must increase the demand for private music concerts. It can be assumed that the local governments which have stronger financial power more effective cultural policies bacause these local governments tend to be in urban area and can cooperate academic organization earsily. The local governments' cultural expenditure on events and education will increase the demand for music concerts.

To try and capture various aspects of the "inefficiencies" in (3), five models are assumed: (A) the pooling Stochastic Frontier (SF) model; (B) the random-effects SF model; (C) the true random-effects SF model; (D) the fixed-effects SF model; and (E) the Battese and Coelli (1992) Time Varying Stochastic Frontier (TV-SF) model. These models can be defined as follows:

Model A: Pooling SF Model

$$\ln Q_{it} = \sum_{r=1}^{n} \beta_r \ln E_{it_r} + \gamma + \delta dm s_{it} + u + v_{it}, \quad u \sim HN(0, \sigma_{\mu}^2), \quad v_{it} \sim N(0, \sigma_{\nu}^2)$$
(4)

Model B: Random-Effects SF Model

$$\ln Q_{it} = \sum_{r=1}^{n} \beta_r \ln E_{it_r} + \gamma + \delta dm s_{it} + u_i + v_{it}, \quad u_i \sim HN(0, \sigma_{\mu}^2), \quad v_{it} \sim N(0, \sigma_{\nu}^2)$$
(5)

Model C: True Random-Effects SF Model

$$\ln Q_{it} = \sum_{r=1}^{n} \beta_r \ln E_{it_r} + \gamma_i + \delta dm s_{it} + u_{it} + v_{it}, \quad u_{it} \sim HN(0, \sigma_{\mu}^2), \quad v_{it} \sim N(0, \sigma_{\nu}^2)$$
$$\gamma_i = \gamma + w_i, \quad w_i \sim N(0, \sigma_{w}^2)$$
(6)

Model D: Fixed-Effects SF Model

$$\ln Q_{it} = \sum_{r=1}^{n} \beta_r \ln E_{it_r} + \gamma + \zeta_i + \delta dm s_{it} + u_i + v_{it}, \quad u_i \sim HN(0, \sigma_{\mu}^2), \quad v_{it} \sim N(0, \sigma_{\nu}^2)$$
(7)

Model E: Battese and Coelli Time Varying SF Model

$$lnQ_{it} = \sum_{r=1}^{n} \beta_r lnE_{it_r} + \gamma + \delta dms_{it} + u_{it} + v_{it}, \qquad u_{it} = exp\{-\eta(t-T)\}u_i$$
$$u_i \sim HN(0, \sigma_{\mu}^2), \quad v_{it} \sim N(0, \sigma_{v}^2), \qquad (8)$$

where u, u_i , and u_{it} are each a measure of technical inefficiency, v_{it} is standard disturbance, γ_i is the random effect to deal with latent heterogeneity, w_i is the disturbance of γ_i , and ζ_i is the individual fixed effect. T is the number of periods in the balanced panel data, and *HN* denotes a half-normal distribution that generates a non-

negative random variable.

Since the pooling model in equation (4) totally ignores the panel nature of the data, it is not considered to be a "panel" model, In equation (4), the null hypothesis of no inefficiency can be tested by testing whether or not $\sigma_{\mu}^2 = 0$. Similarly, in equation (5), the hypothesis of no inefficiency can be tested by testing whether or not $\sigma_{\mu}^2 = 0$. It should be noted that equations (4) and (5) are non-nested models, so it is not possible to choose between them by using standard testing procedures. Equation (5) is nested within equation (6) so that if the parameter controlling the distribution of the random parameter γ_i , σ_w^2 , is significant in equation (6), the true random-effects model, then equation (6) is judged to be more appropriate than the random-effects model given in equation (5). Equation (5) is nested within equation (8), and if the null hypothesis that $\eta = 0$ is accepted, equation (5) is preferred to equation (8). If $\sigma_{\mu}^2 = 0$ is accepted, there is no inefficiency. In this case, we revert to standard panel analysis by estimating a pooling model, a fixed-effects model and random-effects model.

3.5 Data

A balanced panel data set consisting of annual data from 2003 to 2008 on all 47 prefectures in Japan is used in this chapter. Tables 3-1 and 3-2 provide definitions and descriptive statistics for each variable, respectively. The data on live private music entertainment in Japan are drawn from the "White Paper on Live Entertainment 2004-2009" which is constructed by *PIA* Research Institute³. This statistical data is defined

³ By the way, *PIA* Corporation is the largest company selling tickets for live entertainment in Japan. *PIA* has over 19,000 shops including distributors all over Japan. Using such a large marketing network, *PIA* has aggregated the marketing data which they obtained from their shops and has constructed a dataset on live private music entertainment.

as Growth Domestic Entertainment (GDE) by *PIA*. It can be said that GDE data is reliable because *PIA* Research Institute has examined the reliability of the marketing data and has estimated the unobservable marketing data on live entertainment. GDE data has been constructed according to the following standards. The sample data includes data on all private entertainment which required payments and were advertised in public in Japan. In other words, all public entertainment, free entertainment and secret concerts are excluded. The data on private live entertainment is the number of tickets which are sold by *PIA*, while the other data includes estimated values.

The data on local governments' cultural expenditures in Japan are drawn from "the Conditions of the cultural administration in the local area in Japan" (*Chihou ni okeru Bunkagyosei no Jokyo ni tuite*) which is a survey conducted by the Ministry of Education, Culture, Sports, Science, and Technology in Japan. The annual data on population are drawn from the 2003, 2004, 2006, 2007, and 2008 "Population Estimates" (*Jinko Suitei*) and the 2005 "National Census" (*Kokusei Chosa*) which are conducted by the Statistics Bureau and the Director-General for Policy Planning of Japan. The data on the local governments' financial power (*Tannendo Zaiseiryoku Shisu*) are drawn from the "Tables for the Local Governments' Financial Indicators" (*Todoufuken Zaiseishisuhyo*) which is constructed by the Statistics Bureau and the introduction of the DMS to public halls are drawn from the 2003 - 2008 "the membership list of public halls in Japan" (*Zenkoku Kouritsu Bunka Shisetsu Kyougikai KaiinMeibo*) constructed by the Association of Public Theaters and Halls in Japan. In this thesis, the definition of a public hall is any facility which belongs to this membership list, and includes, for example, community centers, music halls, all-

purpose halls, theaters, and libraries with halls.

| Variable | Description | |
|-----------|---|----------------------|
| att_p_c | concert attendance | |
| num_con_p | the total number of the concerts per capita | |
| ave_in | per capita income | |
| finan_p | financial power | |
| cul_ex | local governments' cultural expenditure on | events and education |
| dms_ratio | = public halls with DMS / all public halls | |

Table 3-1: Definition and Description of Variables

Table 3-2: Descriptive Statistics

| Variable | Mean | Std.Dev. | Minimum | Maximum |
|--------------|--------|----------|---------|---------|
| ln att_p_c | -2.547 | 0.704 | -4.180 | -0.436 |
| ln num_con_p | -1.702 | 0.648 | -2.937 | 0.196 |
| ln ave_in | 7.903 | 0.145 | 7.604 | 8.450 |
| ln finan_p | -0.857 | 0.412 | -1.610 | 0.413 |
| ln cul_ex | 12.459 | 1.056 | 8.605 | 16.045 |
| dms_ratio | 0.200 | 0.220 | 0.000 | 0.813 |
| | | | | |

Notes:

The total number of sample size is 282 (=6 years data for 47 prefectures).

3.6 Results and Discussion

Table 3-3 reports the results of estimating equation (3) by panel methods without an efficiency term, while Table 3-4 shows the estimation results when an efficiency term is incorporated. LIMDEP 9.0 is used in estimating all models. A reduced form model for the number of concert tickets sold was estimated using a standard fixed effects model, a fixed effects model with robust standard errors, and a random-effects model. In addition to these non-frontier models, five frontier models which have been explained in Section 3.3 (Models A - E) were estimated, but LIMDEP 9.0 could not compute estimates for the fixed-effects model (Model D). Therefore, the pooling SF model (Model A), the random-effects SF model (Model B), the true random-effects SF model (Model C), and the Battese and Coelli (1992) TV-SF model (Model E) are examined as frontier models.

In all models, the estimated coefficients of the number of concerts and financial power have the expected positive sign, and are statistically significant. The tickets of music concerts have sold well in those prefectures which have strong financial power like Tokyo, Osaka, and Nagoya. The estimated coefficients on average income take different signs across models. The estimated coefficients of the average income have the expected positive sign in Models 2, 3, B, and C, and are statistically significant only in Models B and C. In contrast, the estimated coefficients of the average income are negative, but insignificant in Models 1, A, and E. The estimated coefficients on local governments' cultural expenditure are positive in Models 1, 2, A, B, C, and E but are mostly in significant. In Model 3, the estimated coefficient on local governments' cultural expenditure is negative but insignificant. This suggests that local governments' investments in cultural events and education do not have crowding-in nor crowding-out the demand for private music concerts. The estimated coefficients of the ratio of the public halls with DMS are positive in all models and significant in Models 3, B, and C. This suggests that the introduction of the DMS has contributed to increasing the audiences of private concerts.

The results of estimating the usual panel models (Models 1, 2, and 3) indicates that the fixed effect model (Models 3) is supported since the F test testing the null hypothesis that individual fixed effects are absent rejects the pooling models with a p-value of 0.000, and the Hausman test rejects the random effect models in favor of the fixed effect model with a p-value of 0.024. Therefore, Models 3 is the most appropriate among the nonfrontier models. This implies that technical inefficiencies may be caused by the characteristics of individual prefectures.

Since the estimates of λ are positive and significant in Models B, C, and E, this suggest that there is statistically significant inefficiency. When the results for the pooling SF model (Model A) and the random effects SF model (Model B) are compared, the random-effects SF model (Model B) appears to be the more acceptable model because although the two models contain the same number of parameters the log likelihood of Model B is much better than Model A. When the results for pooling SF model (Model A) and the Battese and Coelli (1992) TV-SF model (Model E) are compared, the latter model (Model E) appears to be the more acceptable model. This is because the log likelihood of Model E is better than Model A. However, the results for Model E suggest that Model E is not accepted because the Wald test of the null of hypothesis of $\eta = 0$ accepts the null hypothesis. When the results for the random-effects SF model (Model B) and the true random effects SF model (Model C) are compared, the true randomeffects model (Model C) appears to be the more acceptable model. The results for Models B suggest that the true random-effects model is supported because the estimated
means for γ_i and the estimated Scale parameters for w_i are statistically significant. Therefore, Models C is the most appropriate among frontier models.

In choosing between Model 3 and Model C, Model 3 is more appropriate because the log likelihood of Model 3 is far better than Model C. Therefore, the fixed-effects model (Model 3) is the most appropriate among all models. In Model 3, the estimated coefficient for average income does not have the expected sign, but is statistically insignificant. In Model 3, the estimated coefficient of the local governments' cultural expenditure is negative, but insignificant. This suggests that there are neither crowding-in effects nor crowding-out effects. The impacts of local governments" cultural investment seem to be almost zero during the estimation periods. In Model 3, the estimated coefficient of the ratio of the public halls that have introduced with the DMS is positive and statistically significant. This result suggests that the introduction of the DMS has increased sales of tickets. The DMS seems to have succeeded in increasing the sales of tickets for live private music entertainment.

| Model | Model 1 | Model 2 | Model 3 |
|-------------------------|---------------|----------------------|---------------|
| Estimation Method | Pooling | Random-effects | Fixed-effects |
| Dependent Variable | | | |
| ln att_p_c | | | |
| Explanatory Variables | | | |
| ln num_con_p | 0.674 | 0.792 | 0.854 |
| | (0.037)*** | (0.054)*** | (0.079)*** |
| ln ave_in | -0.121 | 0.511 | 0.342 |
| | (0.270) | (0.339) | (0.504) |
| ln financial | 0.611 | 0.254 | 0.055 |
| | (0.107)*** | (0.119)** | (0.149) |
| ln culture_expenditure | 0.045 | 0.013 | -0.002 |
| | (0.023)** | (0.022) | (0.025) |
| dms_ratio | 0.050 | 0.109 | 0.191 |
| | (0.105) | (0.080) | (0.089)** |
| constant | -0.495 | -5.209 | |
| | (2.177) | (2.728)* | |
| Log likelihood | -94.605 | -12.313 | 74.773 |
| E tost | Reject | | |
| r test | Pooling Model | | |
| | (0.000) | | |
| Houseman (1079) to st | | Reject | |
| nausman (1978) test | | Random-effects Model | |
| | | (0.024) | |

Table 3-3: Estimated Results of the Panel Models

Notes:

- (1) For each variable, the first line is the coefficient estimate, and the second line is the standard error.
- (2) The models entitled robust standard errors are just fixed effect models with the standard errors that have been computed to make them robust.
- (3) *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.
- (4) The F test reports a p-value for the F-test of the null hypothesis of a pooling model against the alternative hypothesis of a fixed effect model. If the pooling model is rejected, a fixed effects model is accepted.
- (5) The Hausman (1978) test reports a p-value for the Hausman test of the null hypothesis of a random effects model against the alternative hypothesis of a fixed effect model. If the random effects model is rejected, a fixed effects model is accepted.

| Model | Model A | Model B | Model C | Model E | | | |
|--|-----------------------|-------------------|---------------------------|---------------------------|--|--|--|
| Estimation Method | Pooling SF | Random-effects SF | True random-effects SF | Battese & Coelli TV-SF | | | |
| Dependent | | | | | | | |
| Variable | | | | | | | |
| ln att_p_c | | | | | | | |
| Explanatory Variabl | Explanatory Variables | | | | | | |
| ln num_con_p | 0.674 | 0.792 | 0.862 | 0.674 | | | |
| | (0.037)*** | (0.044)*** | (0.024)*** | (0.022)*** | | | |
| ln ave_in | -0.121 | 0.443 | 0.572 | -0.121 | | | |
| | (0.267) | (0.248)* | (0.151)*** | (0.168) | | | |
| ln financial | 0.611 | 0.208 | 0.251 | 0.611 | | | |
| | (0.106)*** | (0.136) | (0.064)*** | (0.072)*** | | | |
| ln culture_expenditure | 0.045 | 0.012 | 0.013 | 0.045 | | | |
| | (0.023)** | (0.024) | (0.013) | (0.014)*** | | | |
| dms_ratio | 0.050 | 0.131 | 0.103 | 0.050 | | | |
| | (0.103) | (0.064)** | (0.050)** | (0.122) | | | |
| constant | -0.495 | -5.158 | | -0.495 | | | |
| | (13.927) | (1.946)*** | | (1.357) | | | |
| constant: means for γ_i | | | -5.739 | | | | |
| | | | (1.204)*** | | | | |
| constant: | | | 0.200 | | | | |
| Scale parameters for w_i | | | 0.300 | | | | |
| | | | (0.013)*** | | | | |
| | | | | | | | |
| σ_v | 0.338 | 0.204 | 0.171 | 0.300 | | | |
| σ_u | 0.000 | 0.544 | 0.185 | 0.260 | | | |
| $\sigma = (\sigma_v^2 + \sigma_u^2)^2$ | 0.338 | 0.581 | 0.004 | 0.397 | | | |
| $\lambda = \sigma_u / \sigma_v$ | 0.000 | 2.662 | 1.083 | 0.867 | | | |
| | (50.958) | (0.836)*** | (0.396)*** | (0.160)*** | | | |
| η | | | | 0.010 | | | |
| | | | | (0.132) | | | |
| | | | | | | | |
| Log likelihood | -94.605 | -13.803 | -11.742 | -98.496 | | | |

Table 3-4: Estimated Results of the Stochastic Frontier Models

Notes:

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

⁽¹⁾ For each explanatory variable and λ , the first line reports the estimated coefficient, and the second line is the standard error.

3.7 Conclusion

This chapter attempts to examine the effect of public cultural policy on private music concerts in Japan, in particular, the possible crowding-in effects of cultural policy and the influence of the Designated Manager System (DMS) on the demand for live private music entertainment. Three channels through which the ticket sales for private music concerts were influenced the local governments' cultural policies are assumed. In the first channel, the DMS shifts the demand function upward. In the second channel, the local governments' cultural policies lead to crowding-in effects indirectly, by shifting the supply curve to the left. In contrast to the second channel, in the third channel, the downward shift of the supply curve leads the crowding-out effect since an inelastic demand is assumed. The first and second channels are examined, by estimating a reduced form equation for ticket sales which is derived from the demand function and supply functions for private concerts. To capture the differences of the performance of the local government's cultural policies, frontier models are also estimated in addition to the non-frontier models. The estimation results support the non-crowding-in hypothesis and show that the DMS has increased sales of tickets for private concerts. The results suggest the DMS has improved the local governments' cultural policies to increase ticket sales for music concerts. Since the behavior of the suppliers of private music concerts has not been examined, this study cannot deny the possibility that the privatization of the public sector may oppress the suppliers of the private music concerts.

PART II. Deregulation in Monopoly Markets: The Electric Power Industry

Chapter 4

The Impact of Liberalization on the Production of Electricity in Japan⁴

4.1 Introduction

Recently inefficiencies in the Japanese electricity market have been the focus of some attention. In particular, even though the liberalization of the electricity market has been phased in and regulations on entry have been relaxed three times since the 1990s, the monopolistic nature of the Japanese electricity market has been the subject of much discussion since the Management and Coordination Agency in Japan (Soumu-cho) proposed energy liberalization (the official website of Federation of Electric Power Companies of Japan: <u>http://www.fepc.or.jp/enterprise/jiyuuka/keii/</u>). There has also been some discussion of the possible separation of electricity generation and transmission. For example, Goto and Inoue (2012) measure the economies of scope between generation and transmission in Japan to examine the effectiveness of diversification in the Japanese electricity industry. This chapter aims to measure the impact of recent liberalizations on the efficiency of electricity production in Japan, and to examine whether or not economies of scope exist between electricity generation and transmission.

A huge literature has examined whether or not inefficiencies exist in various industries including the electricity industry. Papers using a parametric approach tend

⁴ Chapter 4 has published in *Open Journal of Applied Science*.

to estimate a cost function rather than a production function because there are endogeneity problems associated with input choices when estimating a production function. To estimate either a production function or a cost function, papers in the literature either use a parametric approach or a non-parametric approach. Papers using a non-parametric approach typically employ Data Envelopment Analysis (DEA) to measure the inefficiencies among the electricity companies. Papers using DEA measure either productive efficiencies or cost efficiencies, using the variables which are the same as the variables to estimate either the production function or cost function.

For the electricity industry in Japan there are three key papers using Using data from 1978 to 1998, Kuwabara and Ida (2000) parametric approach. estimate a translog cost function for the Japanese electric companies together with share equations. Kuwabara and Ida (2000) aim to measure the extent of economies of scale and economies of scope in the electricity industry in Japan, but they do not examine the impact of the liberalization measures that have been implemented. Their results support the existence of both overall economies of scale and economies of scope for all electric power companies during the period Kuwabara and Ida analyzed. Using data from 1982 to 1997, Nemoto and Goto (2006) estimate a constant elasticity of substitution (CES) cost function, and measure the technical and allocative efficiencies of the transmission-distribution of electricity in Japan. Their results show the existence of technical and allocative inefficiency. The observed costs are estimated to be between 9 to 48% higher than their efficient levels. Kinugasa (2012) measures the Lerner index for each Japanese electric company to examine whether three liberalizations have made the mar-ket more competitive using estimates of translog production functions. Kinugasa's (2012) empirical results show that the three liberalizations have made every

electricity market more competitive. Goto and Inoue (2012) estimate a composite cost function for the Japanese electric companies using data between 1990 and 2008. Goto and Inoue do not use the translog cost function, but rather use a composite cost function which enables them to measure the economies of vertical integration, which includes both the effects of economies of scale and economies of scope, in electricity production. They reports that there were no overall economies of scale and that there were economies of scope. In detail, the economies of scale for generation existed during their sample period, while economies scale for transmission did not exist.

For the electricity industry in Japan, there are two key papers using the DEA approach. Tsutsui (2000) measures the inefficiencies of Japanese electric companies using the Malmquist Index, and then compares the estimated inefficiencies of Japanese electric power companies with those of the U.S. companies between 1992 and 2000. Although his results show that Japanese firms are more efficient than U.S. firms, Tsutsui does not examine the impact of the electricity liberalization. One disadvantage of the DEA approach is that the statistical significance of the input variables cannot be evaluated. Hence, the impact of any liberalization can-not be examined via the DEA statistically. Hattori, Jamasb, and Pollitt (2005) measure the efficiencies of electricity distribution in the U.K. and Japan between 1985 and 1998, using not only stochastic frontier analysis (SFA), but also DEA. Their results show that the Japanese electricity system is less efficient than the U.K. system. Their data period contains only the first electricity liberalization in Japan though Japan experienced three electricity liberalizations in total up to now.

As can be seen from this brief literature survey, the impact of the relaxation of entry restrictions on the inefficiency of Japanese electric companies has not been examined to date using the SFA approach. The first contribution of this study is to examine the impact of the liberalization in the Japanese electricity market by estimating a translog cost function directly. The second contribution of this chapter is to measure the economies of scale and the economies of scope, using estimates of this translog cost function. As a result, the hypothesis that the three electricity liberalizations contribute to reducing the cost of electricity generation and transmission is supported. This result are consists with Kinugasa (2011). The estimates of the overall economies of scale and the economies of scope in this chapter are consisted with the results in Goto and Inoue (2012). The estimated results of this chapter suggest that overall economies of scale did not exist and economies of scope existed.

The rest of this chapter is organized as follows. Section 4.2 provides an outline of the key liberalizations of the electricity market that have been implemented in Japan. Section 4.3 discusses the empirical models that are used to examine the impact of these liberalizations and how this model can be used to check for the existence of economies of scope between electricity generation and electricity transmission, while section 4.4 details the definitions of the variables used and the data sources. Estimation results are reported in section 4.5, and section 4.6 contains a conclusion.

4.2 Liberalization of the Electricity Market

In the 1990s, deregulation to reduce inefficiencies in the electricity market was popular all over the world. At that time, many European countries and the United States deregulated their electricity markets. Since 1995, liberalization of the electricity market in Japan has been phased in and the regulations on entry have been relaxed three times. This liberalization aimed to improve the structural efficiency of firms in the industry and to reduce electricity bills that were said to be higher than the average level paid by consumers in foreign countries (Yamaguchi (2007)).

Table 4-1 summarises the details of the main changes in the electricity market as a result of the liberaliza-tions. Prior to 1995, Japan was divided into ten geographic regions, and within each region a monopoly on power generation and distribution was allocated to one general electric power utility (GEU, *Ippan Denki-jigyousha*). As a result, there are ten general electric power utilities in Japan. These ten companies each engaged in the generation, transmission and distribution of electricity within their respective geographical regions. Apart from GEUs, only wholesale electric power utilities (WEU, Oroshiuri Denkijigyousha) were allowed to generate electric power that was then supplied to GEUs. Only two WEUs existed; the Electric Power Development Company Limited (Dengenkaihatsu) and the Japan Atomic Power Company (Nihon Genshirvo-kuhatsuden). Both companies were started with capital from the GEUs. Private power generation (PPG) was also allowed. In other words, the electricity generation was allowed as long as they sell the electric power to the others. After the collapse of Japan's overheated stock and real estate markets in the early 1990s, higher electricity bills in Japan compared to those paid by consumers in foreign countries became an issue. The Japanese government aimed to improve the efficiency of electricity production by introducing competition into the electric power market.

First, the Electricity Business Act (*Denkijigyouhou*) was revised to enable wholesale suppliers (WS) to enter the wholesale markets for electricity supply. This revision was enacted in December 1995. The typical example of a WS is an independent power producer (IPP, *Dokuritsukei Hatsudenjigyousha*). IPPs include not only the subsidiaries of GEUs but also companies like steel companies which have the knowhow to generate electric powers. In this context, the wholesale market for electricity refers to the generation of electricity in Japan. The electricity generated by the new entrants was sold to the general power companies, and then supplied to consumers through the transmission sectors owned and operated by the general electricity utilities. Since the first revision of the Electricity Business Act, the specified electricity utilities (SEU, *Tokutei Denki-jigyousha*), who have a duty to generate, distribute, and sell electricity only for the specified areas, have started to generate and distribute electricity. However, the area served by a SEU has been an independent market.

In March 2000, the Electricity Business Act was revised again so that power producer and suppliers (PPS, *Tokuteikibo Denkijigyousha*) could enter the retail markets for electricity, that is, PPS could sell electricity directly to consumers. This revision permitted new entry of suppliers into the retail market for electricity for consumers with an electric power contract of over 2,000 kW. The remaining part of the retail market, that is, for small contract consumers, was maintained as a monopoly of the relevant regional electric power company. That is why this second revision is called a partial liberalization.

In 2003, the Electricity Business Act was revised to allow entry in April 2004 into the retail market where each consumer's electric power contract was over 500 kW, and then where each consumer's electric power contract was over 50 kW in April 2005. In short, this revision expanded the sections of the retail market where the PPSs could enter. That is why this is called an expansion of the partial liberalization. Moreover, the market rules for the electricity transmission sector and a watchdog organization (*Souhaidengyoutou Gyomush-ienkikan*) have been established to realize fair deals. An examination of how the retail market shares of various operators have changed after the electricity liberalization began shows that the maximum market share of the PPSs was 0.74 % after the PPS entered the re-tail market (Minister of Economy, Trade and Industry (2011), p. 32). The ten main electric power companies have been able to maintain a market share of 70 - 80 % even after the electricity liberalization (Minister of Economy, Trade and Industry (2011), p. 32). However, as a result of new entry, electricity prices have fallen. After the electricity liberalization began, average prices have tended to decline. This fact suggests that the existence of innovation by competition might have led to lower prices.

| Year | Generation | Wholesale | Distribution | Liberalized Retail Market | | The Other |
|------------------------------|---------------|---------------|--------------|---------------------------|-----------------|-----------|
| | | Market | & Sales | Lighting Sector | Industry Sector | |
| January, 1970 – March, | GEU | | GEU | No change | No change | No change |
| 1995 | WEU | WEU | | | | |
| | PPG | PPG | | | | |
| April, 1995 – February, 1999 | GEU | | GEU | - | | SEU |
| | WEU | WEU | | | | |
| | PPG | PPG | | | | |
| | WS (IPP etc.) | WS (IPP etc.) | | | | |
| March, 2000 – March, 2003 | GEU | | GEU | - | Over 2,000 kW | - |
| April, 2004 – March, 2005 | W EU | WEU | | | Over 500 kW | |
| April, 2005 – | PPG | PPG | | | Over 50 kW | - |
| | WS (IPP etc.) | WS (IPP etc.) | | | | |
| | | | PPS | | | |

Source: Constructed by the author based on information on Tokyo Electric's web site (http://www.tepco.co.jp)

Figure 4-1 shows declines in the average electricity prices for households and industry around the time of the liberalizations. After the first electricity liberalization, the average electricity prices for households and industry tend to decline. Though Figure 4-1 suggests that all of three liberalizations seemed to be effective, there is a possibility that innovation in electric power generation affects electricity prices. Therefore, in the next section, the impacts of these three-step-liberalizations on the production of electricity are examined, using an econometric model.



Figure 4-1: Average Electricity Prices

Source: Constructed by the author using data from the "Electricity Statistics Information (*Denryoku Toukeijouhou*)" published by the Federation of Electric Power Companies of Japan.

Notes: The three vertical lines show the years when the three electricity liberalizations were enacted.

4.3 Model

4.3.1 Translog Cost Function with Inefficiency Term

Assume that in the generation, transmission and distribution of electricity there are three inputs, labor, capital and fuel, and two outputs, the generation of electricity, and the transmission and distribution of electricity. These inputs and outputs are assumed to be related by a translog cost function. The number of inputs and the number of outputs are defined following Goto and Inoue (2012). The outputs are measured as the total quantity electric power sold in a fiscal year and the total length of transmission routes, respectively. This assumption makes it easier to estimate the economies of scope between the generation and transmission and distribution sectors. To measure the inefficiency due to technical factors, a stochastic frontier version of the translog cost function is employed. Once the symmetry of the second derivatives of the cost function with respect to two different input prices is taken into account, the stochastic frontier translog cost function can be written as follows:

$$\ln TC_{it} = \alpha_0 + \alpha_1 \ln y_{1it} + \alpha_2 \ln y_{2it} + \beta_1 \ln p_{1it} + \beta_2 \ln p_{2it} + \beta_3 \ln p_{3it} + \gamma_{11} \frac{1}{2} (\ln y_{1it})^2 + \gamma_{22} (\ln y_{2it})^2 + \gamma_{12} \ln y_{1it} \ln y_{2it} + \delta_{11} \frac{1}{2} (\ln p_{1it})^2 + \delta_{22} \frac{1}{2} (\ln p_{2it})^2 + \delta_{33} \frac{1}{2} (\ln p_{3it})^2 + \delta_{12} \ln p_{1it} \ln p_{2it} + \delta_{23} \ln p_{2it} \ln p_{3it} + \delta_{31} \ln p_{3it} \ln p_{1it} + \rho_{11} \ln y_{1it} \ln p_{1it} + \rho_{11} \ln y_{1it} \ln p_{1it} + \rho_{11} \ln p$$

 $\rho_{12} \ln y_{1it} \ln p_{2it} + \rho_{13} \ln y_{1it} \ln p_{3it} + \rho_{21} \ln y_{2it} \ln p_{1it} + \rho_{22} \ln y_{2it} \ln p_{2it} + \rho_{23} \ln y_{2it} \ln p_{3it} + \tau_1 D_{1t} + \tau_2 D_{2t} + \tau_3 D_{3t} + \ln t + \varphi_{thermal} thermal_{it} + \varphi_{nuclear} nuclear_{it} + \varphi_{new} new_{it} + u_{it} + v_{it}.$

(1)

$$\ln TC_{it} = f(\cdot) + u_{it} + v_{it},\tag{2}$$

where TC_{it} is the total cost of the i-th firm at time t, y_{jit} is the quantity of the j-th output for the i-th firm at time t, p_{kit} is the observed price of the k-th input for the i-th firm at time t, D_{st} is a 0-1 dummy variable taking the value of 1 if at time t the s-th change of the electricity liberalization has been implemented (s=1,2,3) and zero otherwise, t is a time trend, thermal_{it} is the ratio of thermal power generation to hydroelectric generation for the i-th firm at time t, nuclear_{it} is the ratio of nuclear power generation to hydroelectric generation for the i-th firm at time t, new_{it} is the ratio of new energy generation to hydroelectric generation for the i-th firm at time t, a_j , β_k , γ_{jl} , δ_{km} , ρ_{jk} , τ_s , $\varphi_{thermal}$, $\varphi_{nuclear}$, and φ_{new} are coefficients to be estimated, u_{it} is the inefficiency term for the i-th firm at time t, and v_{it} is a standard disturbance. In this model, it is assumed that all firms have the same production technology.

4.3.2 Method for Estimation of Economies of Scope

When a 2 output cost function is assumed, the economies of scale for y_{it} is defined as

$$s_{oit} = \frac{MC_{it}}{AC_{it}} = \frac{\partial TC_{it}}{\partial y_{oit}} \cdot \frac{y_{oit}}{TC_{it}} = \frac{\partial \ln TC_{it}}{\partial \ln y_{oit}},\tag{3}$$

where s_{oit} is the economies of scale for the o-th output, MC_{it} is marginal cost, and AC_{it} is average cost. Equation (3) means that there are economies of scale when average cost is larger than marginal cost. Therefore, when s_{oit} is larger than 1, there are no economies of scale. When s_{oit} is less than 1, there are economies of scale.

In the case of this chapter, the economies of scale for y_{1it} and y_{2it} are defined

$$s_{1it} = \alpha_1 + \gamma_{11} \ln y_{1it} + \gamma_{12} \ln y_{2it} + \rho_{11} \ln p_{1it} + \rho_{12} \ln p_{2it} + \rho_{13} \ln p_{3it}, \tag{4}$$

$$s_{2it} = \alpha_2 + \gamma_{22} \ln y_{1it} + \gamma_{12} \ln y_{1it} + \rho_{21} \ln p_{1it} + \rho_{22} \ln p_{2it} + \rho_{23} \ln p_{3it}.$$
 (5)

In the case of two outputs, the overall economies of scale are measured as follows:

$$SCL_{it} = \frac{MC_{it}}{AC_{it}} = MC_{it} \cdot \frac{y_{it}}{TC_{it}} = \frac{y_{it}MC_{it}}{TC_{it}} = \frac{y_{1it}\frac{\partial \ln TC_{it}}{\partial \ln y_{1it}} + y_{2it}\frac{\partial \ln TC_{it}}{\partial \ln y_{1it}}}{TC_{it}}.$$
(6)

When (6) is larger than 1, there are no economies of scale. On the other hand, when (6) is less than 1, there are economies of scale. Combining (3) and (6), the overall economies of scale can be defined as

$$SCL_{it} = \frac{y_{1it}s_{1it} + y_{2it}s_{2it}}{TC_{it}}.$$
(7)

4.3.2 Method for Estimation of Economies of Scale

Baumol, Panzar and Willing (1982) define economies of scope as being complementary if

$$\frac{\partial^2 T C_{it}}{\partial y_{1it} \, \partial y_{2it}} < 0. \tag{8}$$

One interpretation of equation (8) is that for costs to be complementary the marginal cost of each output will decline when the amount of the other output increases. The second derivative on the left hand side of equation (8) can be computed using (1) as:

$$\frac{\partial^2 TC_{it}}{\partial y_{1it} \partial y_{2it}} = \left(\frac{TC_{it}}{y_{1it} y_{2it}}\right) \left[\frac{\partial \ln TC_{it}}{\partial \ln y_{1it} \partial \ln y_{2it}} + \frac{\partial \ln TC_{it}}{\partial \ln y_{1it}} \cdot \frac{\partial \ln TC_{it}}{\partial \ln y_{2it}}\right] = \left(\frac{TC_{it}}{y_{1it} y_{2it}}\right) [\gamma_{12} + s_{1it} \cdot s_{2it}].$$
(9)

In equation (9), $\left(\frac{TC_{12}}{y_1y_2}\right)$ is always positive because TC_{12} , y_1 , and y_2 are all positive. Therefore, to see if (9) is satisfied, it is only necessary to examine the sign of the following expression:

$$SCP_{it_{12}} = \gamma_{12} + s_{1it} \cdot s_{2it}.$$
 (10)

Since this is a function of unknown parameters and the values of the explanatory variables, it needs to be evaluated using estimates of the parameters and the sample values of the explanatory variables.

4.3.3 Estimated Model

Equation (1) with $u_{it}=0$ gives rise to a simple pooling model was given. Since the data being used to estimate the cost function are panel data, it is natural to estimate equation (1) allowing for inidvidual firm effects that are either fixed and random effects. In this case, u_{it} is a time-invariant random variable that is correlated with the explanatory variables for the fixed effects model. In addition to these standard panel models, some stochastic frontier models are estimated in this study to allow for possible existence of stochastic inefficiencies. To try and capture any cost inefficiencies, four models are assumed: the pooling Stochastic Frontier (SF) model; the random-effects SF model; the fixed-effects SF model; and the Battese and Coelli (1992) Time Varying Stochastic Frontier (TV-SF) model. The estimated models are as follows;

Pooling Stochastic Frontier Model

$$\ln TC_{it} = f(\cdot) + u_{it} + v_{it}, \qquad u_{it} \sim HN(0, \sigma_{\mu}^2), \quad v_{it} \sim N(0, \sigma_{v}^2), \tag{11}$$

Tine Invariant SF Model

$$\ln TC_{it} = f(\cdot) + u_i + v_{it}, \qquad u_i \sim HN(0, \sigma_{\mu}^2), \quad v_{it} \sim N(0, \sigma_{v}^2), \tag{12}$$

Fixed-Effects SF Model

$$\ln TC_{it} = f(\cdot) + \zeta_i + u_i + v_{it}, \qquad u_i \sim HN(0, \sigma_\mu^2), \quad v_{it} \sim N(0, \sigma_v^2), \tag{13}$$

Battese and Coelli Time Varying SF Model

$$\ln TC_{it} = f(\cdot) + u_{it} + v_{it}, u_{it} = \exp\{-\eta(t - T_i)\}u_i, \quad u_i \sim HN(0, \sigma_{\mu}^2), v_{it} \sim N(0, \sigma_{v}^2), (14)$$

where u_i , and u_{it} are measures of technical inefficiency, v_{it} is standard disturbance, ζ_i is the individual fixed effect, T_i is the number of observations on firm I in the panel data set, N and HN denote a normal distribution and a half normal distribution, respectively. The difference between models (11), (12), (13) and (14) lies in the specification of the inefficiency term. Models (11), (13), and (14) take no account of the panel nature of the data, while model (12) does. It should be noted that models (11) and (12) are non-nested models, while equation (12) can be obtained as a special case of equation (13) by imposing the restriction $\zeta_i = 0$ for all i, and as a special case of equation (14) by imposing the restriction $\eta = 0$. The pooling model can be obtained as a special case of equations (11) and (12) by imposing the restriction $\sigma_{\mu}^2 = 0$. If $\sigma_{\mu}^2 = 0$ in all these models, then the pooling model is chosen. The standard fixed effects models is nested within equation (13) and can be obtained by imposing $\sigma_{\mu}^2 = 0$. The standard random effects model and any one of the stochastic frontier models are non-nested models.

4.4 Data

Data on the corporate accounts of the ten general electricity utilities are drawn from the "Electricity Statistics Information (*Denryoku Toukeijouhou*)" published by the Federation of Electric Power Companies of Japan. Though ten general electricity utilities have existed in Japan since 1970, *Okinawa Electric Power Company* is excluded from the analysis in this study. The reason for this is that electricity production by *Okinawa Electric* has some important characteristics that differ from other companies. For example, the scale of electricity production at *Okinawa Electric* is much smaller than at the other companies. In addition, *Okinawa Electric* is the only general electricity utility not using nuclear energy for electric power generation. Finally, the prefecture of *Okinawa* is made up of a number of small islands where *Okinawa Electric* is obliged to generate and supply electricity. As a result, it is thought that *Okinawa Electric Power Company* has a unique production function and a unique cost function. Hence, a balanced panel data set consisting of annual data on the other nine general electricity utilities from 1970 to 2010 is used.

 TC_{12} is total costs measured in million yen. The output in the electricity generation sector, y_{1it} , is defined as the total quantity of electric power sold to consumers in the lighting and power sectors (MWh). The output in the transmission sector, y_{2it} , is defined as the length in kilometers of the transmission route including both overhead and underground routes. The unit fuel cost, p_{1it} (million yen), is defined as

$$p_{1it} = \frac{(\text{total fuel expenses})_{it}}{(\text{total quantity of fuel inputs})_{it}}.$$
(15)

The gross fixed capital is employed for the cost of capital, p_{2it} (million yen). It is defined as

$$p_{2it} = (DE_{it}/GFC_{it-1}) + LPR_t, \tag{16}$$

$$GFC_{it-1} = EUFA_{it-1} + FAP_{it-1} + IA_{it-1},$$
 (17)

where p_{2it} is the cost of capital for the i-th firm in year t, DE_{it} is the depreciation expenses for the i-th firm in year t, GFC_{it-1} is the gross fixed capital for the i-th firm in year t - 1, LPR_t is the long-term prime rate for loans made by the main Japanese banks in year t, $EUFA_{it-1}$ is the fixed assets for the i-th firm in year t - 1, FAP_{it-1} is the fixed assets in process for the i-th firm in year t - 1, and IA_{it-1} is investment and other assets for the i-th firm in year t - 1. Data on the long-term prime rate for loans made by the main Japanese banks are drawn from the "Bank of Japan Statistics" published by Bank of Japan. The personal expenses per worker per year, p_{3it} (million yen), is defined as

$$p_{3it} = \frac{(\text{personal expenses})_{it}}{(\text{the number of workers})_{it}}.$$
(18)

 D_1 is a 0 - 1 dummy variable taking the value of 1 in 1995 – 2010, D_2 is a 0 - 1 dummy variable taking the value of 1 in 2001 – 2010, and D_3 is a 0 - 1 dummy variable taking the value of 1 in 2004 – 2010. These three dummy variables correspond to the three entry related liberalizations discussed in section 4.2.

Table 4-2 provides desciptive statistics on all the relevant variables. The variables LNC, LNY1, LNY2, LNP1, LNP2, and LNP3 in Table 4-2 refer to the natural logs of TC_{it} , y_{1it} , y_{2it} , p_{1it} , p_{2it} , p_{3it} , respectively. The variable LNT in Table 4-2

refers to the natural log of the year. The variables THERMAL, NUCLEAR, and NEW in Table 4-2 are the ratio of the quantities of electricity generation of thermal power, nuclear power, and new energy to hydraulic power, respectively.

| Variable | Mean | Std.Dev. | Minimum | Maximum |
|----------|--------|----------|---------|---------|
| LNC | 13.588 | 0.992 | 10.874 | 15.682 |
| LNY1 | 17.684 | 0.847 | 15.817 | 19.511 |
| LNY2 | 8.977 | 0.594 | 7.829 | 9.957 |
| LNP1 | -3.734 | 0.546 | -5.256 | -2.685 |
| LNP2 | 1.543 | 0.631 | 0.472 | 2.299 |
| LNP3 | 2.041 | 0.505 | 0.676 | 2.751 |
| D1 | 0.390 | 0.488 | 0 | 1 |
| D2 | 0.244 | 0.430 | 0 | 1 |
| D3 | 0.171 | 0.377 | 0 | 1 |
| LNT | 7.596 | 0.006 | 7.586 | 7.606 |
| THERMAL | 5.699 | 3.159 | 0.537 | 17.145 |
| NUCLEAR | 2.639 | 2.791 | 0.000 | 12.955 |
| NEW | 0.026 | 0.083 | 0.000 | 0.462 |

Table 4-2: Descriptive Statistics

All sample size is 369. The data for fiscal from 1970 to 2010 is used except Okinawa firm.

4.5 Result and Discussion

LIMDEP 10 (Greene (2005)) is used to obtain all the estimates presented in Table 4-3. With the exception of the pooling stochastic frontier model (equation (11), and denoted Model D in Table 4-3) estimates of the stochastic frontier models could not be obtained because the distribution of the estimated inefficiencies are not consist with the assumptions. In all models in Table 4-3 (Models A - D), all of the estimated coefficients of three dummy variables associated with the electricity liberalization are negative and significant. This suggests that the three entry liberalizations have had some impact in cutting costs. The estimated coefficients associated with the time trend are positive and significant in all models. While technical innovation might be expected to lead to reductions in the cost of generation over time, stricter environmental and safety standards can be expected to have increased production costs over time. The coefficients of the ratio of thermal power, nuclear power, and new energy to hydroelectric power differ between the non-frontier models and the frontier models. In both nonfrontier models and frontier models, the coefficients of thermal power are positive and significant in models A and D, but insignificant in models B and C. Before the coefficients of nuclear power and new energy are discussed, the models are specified.

In choosing between the usual panel models (Model A, B, and C) and frontier model (Models D), the usual panel models are supported for the following reason. In Model D, the estimate of λ are positive and significant in all cases, and this suggests that there is a statistically significant inefficiency. Nevertheless, the value of the maximized loglikelihood of Model D is smaller than the value for the usual panel models (Model B and Model C). In addition to this, the assumption that the cost function is increasing function in $y_{1it}, y_{2it}, p_{1it}, p_{2it}$, and p_{3it} is satisfied only in some samples. For Model D, Table 4-4 reports some descriptive statistics for the estimates of the cost efficiencies for each power utility. The cost efficiencies are calculated as $\exp(-u_{it})$, using the estimates of the inefficiency terms. The cost efficiencies range from 0 to 1, with larger values of cost efficiency meaning a firm is more efficient. The largest value of cost efficiency is 0.983 (Tohoku Electric), while the smallest value is 0.769 (Chugoku Electric). All values of the average cost efficiency for each electricity company exceed 0.9. This suggests that all companies are quite cost efficient.

In choosing among the usual panel models (Models A, B, and C), the fixed-effects model (Model) C is supported since the F test testing the null hypothesis that individual fixed effects are absent rejects the pooling models with a p-value of 0.000, and the log likelihood of the fixed-effects model is the largest among the usual panel models. LIMDEP 10 could not obtain the result of the Hausman test because the inverse of the covariance matrix for Hausman test could not be calculated. In the fixed-effect model, the assumption that the cost function is an increasing function in $y_{1it}, y_{2it}, p_{1it}, p_{2it}$, and p_{3it} is satisfied in the almost samples except for y_{2it} . Because the estimated coefficient of nuclear power is negative and significant in Model C, the use of nuclear power seems to have contributed to reducing costs. Because the estimated coefficient of new energy is positive and significant in Model C, the use of new energy seems to increase costs.

| | Model A | Model B | Model C | Model D |
|----------|-------------|----------------|---------------|-------------|
| | Pooling | Random-effects | Fixed-effects | Pooling SF |
| Constant | -211.725*** | -189.279*** | | -186.749*** |
| | (45.918) | (44.125) | | (42.011) |
| LNY1 | 1.828*** | 0.730 | 0.618 | 1.516*** |
| | (0.598) | (0.972) | (1.507) | (0.549) |
| LNY2 | -4.482*** | -1.398 | 0.002 | -3.916*** |
| | (0.998) | (1.260) | (1.989) | (0.952) |
| LNP1 | 0.875 | 0.786 | 1.111** | 1.005* |
| | (0.553) | (0.509) | (0.520) | (0.513) |
| LNP2 | 0.245 | 0.580 | 0.549 | 0.265 |
| | (0.581) | (0.549) | (0.596) | (0.516) |
| LNP3 | 1.896** | 1.996** | 0.734 | 2.444*** |
| | (0.753) | (0.777) | (0.954) | (0.713) |
| LNY1_2 | 3582*** | -0.146 | -0.030 | 3159*** |
| | (0.093) | (0.118) | (0.166) | (0.088) |
| LNY2_2 | 61899*** | 39693* | -0.006 | 59851*** |
| | (0.190) | (0.235) | (0.349) | (0.183) |
| LNY1LNY2 | 0.592*** | 0.304* | 0.021 | 0.547*** |
| | (0.142) | (0.160) | (0.209) | (0.137) |
| LNP1_2 | 0.236*** | 0.243*** | 0.241*** | 0.251*** |
| | (0.059) | (0.054) | (0.055) | (0.054) |
| LNP2_2 | 0.032 | 0.000 | 0.042 | 0.019 |
| | (0.075) | (0.070) | (0.072) | (0.067) |
| LNP3_2 | -0.315** | -0.295** | -0.287** | -0.378*** |
| | (0.150) | (0.139) | (0.144) | (0.138) |
| LNP1LNP2 | 0.146*** | 0.181*** | 0.218*** | 0.129** |
| | (0.055) | (0.051) | (0.053) | (0.052) |
| LNP2LNP3 | 0.264*** | 0.281*** | 0.391*** | 0.218** |
| | (0.092) | (0.087) | (0.092) | (0.086) |
| LNP1LNP3 | 0.054 | 0.069 | 0.062 | 0.067 |
| | (0.064) | (0.059) | (0.060) | (0.060) |
| LNY1LNP1 | -0.015 | -0.029 | -0.067** | -0.026 |
| | (0.030) | (0.027) | (0.029) | (0.028) |
| LNY1LNP2 | -0.098*** | -0.078** | -0.036 | -0.100*** |
| | (0.036) | (0.036) | (0.043) | (0.031) |
| LNY1LNP3 | 0.018 | -0.008 | 0.025 | -0.006 |
| | (0.048) | (0.052) | (0.066) | (0.043) |

Table 4-3: Estimated Results of Cost Function

Continued to the next page

| | Model A | Model B | Model C | Model D |
|---|-----------|----------------|---------------|------------|
| | Pooling | Random-effects | Fixed-effects | Pooling SF |
| LNY2LNP1 | 0.017 | 0.048 | 0.079** | 0.030 |
| | (0.037) | (0.034) | (0.035) | (0.035) |
| LNY2LNP2 | 0.165*** | 0.104** | 0.004 | 0.172*** |
| | (0.052) | (0.050) | (0.059) | (0.047) |
| LNY2LNP3 | -0.162** | -0.119* | -0.063 | -0.142** |
| | (0.065) | (0.063) | (0.072) | (0.060) |
| D1 | -0.070*** | -0.066*** | -0.058** | -0.072*** |
| | (0.026) | (0.024) | (0.024) | (0.027) |
| D2 | -0.153*** | -0.141*** | -0.151*** | -0.150*** |
| | (0.025) | (0.023) | (0.023) | (0.023) |
| D3 | -0.157*** | -0.127*** | -0.120*** | -0.154*** |
| | (0.028) | (0.026) | (0.027) | (0.028) |
| LNT | 29.105*** | 25.499*** | 41.691*** | 25.778*** |
| | (5.925) | (5.690) | (6.851) | (5.435) |
| THERMAL | 0.007*** | 0.002 | 0.004 | 0.007*** |
| | (0.002) | (0.003) | (0.0039 | (0.002) |
| NUCLEAR | -0.002 | -0.010*** | -0.008* | 0.000 |
| | (0.003) | (0.004) | (0.004) | (0.003) |
| NEW | 0.055 | 0.212** | 0.366*** | 0.009 |
| | (0.082) | (0.084) | (0.091) | (0.077) |
| σ_u | | | | 0.103 |
| σ_v^2 | | | | 0.002 |
| σ_u^2 | | | | 0.011 |
| $\sigma = \sqrt{\sigma_v^2 / \sigma_u^2}$ | | | | 0.114*** |
| | | | | (0.000) |
| $\lambda = \sigma_u / \sigma_v$ | | | | 2.132*** |
| | | | | (0.274) |
| Log likelihood | 416.887 | 425.997 | 456.415 | 421.3133 |

Table 4-3: Continued

Notes:

(1) For each explanatory variable and λ , the first line reports the estimated coefficient, and the second line reports the standard error.

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

| Firm | Mean | Std.Dev. | Minimum | Maximum |
|----------|-------|----------|---------|---------|
| Hokkaido | 0.926 | 0.049 | 0.814 | 0.982 |
| Tohoku | 0.901 | 0.061 | 0.777 | 0.983 |
| Tokyo | 0.922 | 0.038 | 0.82 | 0.974 |
| Chubu | 0.937 | 0.024 | 0.863 | 0.978 |
| Hokuriku | 0.937 | 0.035 | 0.812 | 0.980 |
| Kansai | 0.927 | 0.036 | 0.829 | 0.979 |
| Chugoku | 0.910 | 0.055 | 0.769 | 0.980 |
| Shikoku | 0.908 | 0.040 | 0.790 | 0.974 |
| Kyushu | 0.935 | 0.042 | 0.772 | 0.977 |
| All | 0.923 | 0.045 | 0.769 | 0.983 |

Table 4-4: Estimated Results of Cost Efficiencies: Descriptive Statistic

Estimates from the fixed effects model (Model C) are used to determine whether economies of scale exist and whether economies of scope exist Table 4-5 reports some descriptive statistics for the estimates of economies of scale. Since the mean of the estimates of s_{1it} for each power utility is under 1, these results suggest that economies of scope exist in the generation sector. The problem is that the mean estimates of s_{2it} for each power utility is negative. One possible reason for this is that the cost of transmission includes investment in plant and equipment. Since the mean of the estimates of the ovrall economies of scale, SCL_{it} , for each power utility is over 1, these results suggest that overall economies of scope does not exist.

| Economies of scale for electricity generation | | | | | |
|---|-------|----------|---------|---------|--|
| Firm | Mean | Std.Dev. | Minimum | Maximum | |
| All | 0.522 | 0.047 | 0.411 | 0.630 | |
| | | | | | |

Table 4-5: Estimated Results of Economies of Scale

| Economies of scale for electricity transmission | | | | |
|---|--------|----------|---------|---------|
| Firm | Mean | Std.Dev. | Minimum | Maximum |
| All | -0.098 | 0.046 | -0.214 | 0.014 |

| Overall economies of scale | | | | | |
|----------------------------|--------|----------|---------|---------|--|
| Firm | Mean | Std.Dev. | Minimum | Maximum | |
| Hokkaido | 35.658 | 18.892 | 19.553 | 95.343 | |
| Tohoku | 32.805 | 19.732 | 17.106 | 97.198 | |
| Tokyo | 31.610 | 16.472 | 16.815 | 83.033 | |
| Chubu | 35.346 | 18.409 | 18.168 | 93.520 | |
| Hokuriku | 38.365 | 21.476 | 20.890 | 108.251 | |
| Kansai | 34.213 | 18.421 | 19.016 | 94.478 | |
| Chugoku | 35.474 | 19.405 | 17.694 | 94.531 | |
| Shikoku | 32.888 | 17.845 | 18.511 | 89.100 | |
| Kyushu | 32.885 | 15.050 | 18.201 | 77.712 | |
| All | 34.360 | 18.397 | 16.815 | 108.251 | |

Figure 4-2 displays estimates of the overall economies of scale for each power utility from 1970 to 2010. Movements of the overall economies of scale for all companies are more or less the same during the period. In the 1970s, SCL_{it} declined rapidly, and then, SCL_{it} has been increasing slowly. The estimated value of SCL_{it} exceeds 1 throughout the period. Though this means that overall economies scale have not been existed during this period, the econoies of scales for generation and transmission was improved in the 1970s. In the 1970s, Japan started to convert to nuclear power in earnest after the oil shock. It is considered that the saving on oil use contributed to the economies of scales.



Figure 4-2: Overall Economies of Scale over Time

Table 4-6 reports some descriptive statistics for estimates of SCP_{12} for each power utility. Since the mean of the estimates of SCP_{12} for each power utility is negative, these results suggest that economies of scope exist between the generation sector and transision sector for electricity on average.

| Firm | Mean | Std.Dev. | Minimum | Maximum |
|----------|--------|----------|---------|---------|
| Hokkaido | -0.050 | 0.023 | -0.093 | -0.008 |
| Tohoku | -0.034 | 0.025 | -0.071 | 0.014 |
| Tokyo | -0.012 | 0.020 | -0.041 | 0.027 |
| Chubu | -0.026 | 0.026 | -0.066 | 0.021 |
| Hokuriku | -0.050 | 0.035 | -0.114 | 0.013 |
| Kansai | -0.013 | 0.021 | -0.047 | 0.025 |
| Chugoku | -0.037 | 0.028 | -0.079 | 0.017 |
| Shikoku | -0.037 | 0.024 | -0.078 | 0.013 |
| Kyushu | -0.031 | 0.023 | -0.061 | 0.014 |
| All | -0.032 | 0.028 | -0.114 | 0.027 |

Table 4-6: Estimated Results of Economies of Scope

4.6 Conclusion

This chapter measures the impact of liberalization on the cost efficiency of electricity production in Japan, and examines whether or not economies of scale and economies of scope exist between electricity generation and transmission. The estimation results suggest that production costs have fallen significantly following each of the three entry-related liberalizations, and support the existence of economies of scope. While the existence of overall economies of scale is not supported, economies of scale become much stronger in the 1970s. One notable result is that the estimated coefficient of the time trend is positive. This may mean that there are factors which have reduced cost efficiencies. There is a possibility of improving the inefficient factors by further liberalization in the electricity generation and distribution sectors. The structural separation of the transmission sector of electricity from the generation of electric power, which has been discussed recently, is one example of a further liberalization. However, considering the existence of the scope of economies between the generation sector and the transmission sector, other kinds of liberalization should be introduced.

Chapter 5

Concluding Remarks: Methodological and Policy Implications

This thesis aims to examine the impact of some deregulations in Japan, using frontier analysis. Two kinds of current deregulation, the deregulation of the public sector and the deregulation of the private sector, are picked up; the Designated Manager System (DMS) and electricity liberalization. While Chapters 2 and 3 examine the impact of the DMS which has introduced into public halls, Chapter 4 examines the impact of electricity liberalization. A brief summary of each chapter follows.

Chapter 2 measures the impact of the DMS on the management cost of public halls, places where cultural activities and cultural events are supplied. In this study, only the efficiency of the production costs for cultural events is measured. 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 improve. As a result, it appears that the DMS has contributed to some public halls cutting their costs. These results suggest that the DMS has contributed to improving the 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 public halls. 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 for some public halls 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.

While Chapter 2 attempts to examine the impact of the DMS on the supply side, Chapter 3 attempts to analyze the impact on the demand side by examining the effect of public cultural policy on private music concerts in Japan, in particular, the possible crowding-in effects of cultural policy and the influence of the Designated Manager System (DMS) on the demand for live private music entertainment. Three channels through which ticket sales for private music concerts were influenced by the local governments' cultural policies are assumed. In the first channel, that the DMS shifts the demand function upward. In the second channel, the local governments' cultural policies lead to crowding-in effects indirectly, by shifting the supply curve to left. In contrast to the second channel, in the third channel, the downward shift of the supply The curve leads to a crowding-out effect since demand is assumed to be price inelastic. first and second channels are examined, by estimating the reduced form equation for ticket sales which is derived from the demand function and supply functions for private concerts. To capture the differences in the performance of local government's cultural policies, frontier models are also estimated in addition to non-frontier models. The estimation results support the non-crowding-in hypothesis and show that the DMS has increased sales of tickets for private concerts. The results suggest the DMS has improved the local governments' cultural policies to increase ticket sales for music
concerts.

Chapter 4 measures the impact of liberalization on the cost efficiency of electricity production in Japan, and examines whether or not economies of scope exist between electricity generation and transmission. The estimation results suggest that production costs have fallen significantly following each of the three entry-related liberalizations and the existence of economies of scope on average. One notable result is that the coefficient of the time trend is positive. This may means that the existence of a factor(s) which has reduced cost efficiencies. There is a possibility of improving the inefficient factors by further liberalization in the electricity generation and distribution sectors. The structural separation of the transmission sector of electricity from the generation of electric power, which has been discussed recently, is one example for further liberalization. However, considering the existence of the scope of economies between the generation and transmission sectors, other kinds of liberalization should be introduced.

Overall, the major contribution of this thesis is to propose methods and applications to measure the impacts of deregulation using frontier functions. Part I (Chapters 2 and 3) discusses how to measure the impacts of a particular type of privatization of public facilities, the Designated Manager System (DMS), which was intended to introduce market mechanisms into the public sector. Part I also discusses the difficulties in applying the concept of efficiency into the public sector where institutions are not necessarily intended to maximize their profits. However, the DMS introduced into public halls was intended to reduce the wastefulness of management costs. Thus, it is considered that frontier analysis can be applied to measure the impact of the DMS. Chapter 2 has proposed how to measure the productive efficiency of Japanese public halls, while Chapter 3 has proposed how to examine whether public cultural policies to expand the demand for art and culture has succeeded or not. Chapter 3 theoretically indicated how to measure the different impacts of cultural policies implemented by local governments using the frontier function. Part II (Chapter 4) discussed the impacts of deregulation in a monopoly market and has proposed how to measure the impact of the liberalization of the electricity markets by estimating a cost frontier function. The empirical findings of these chapters suggest some policy implications, as discussed earlier. In this thesis, the focus is mainly on the efficiency of management costs. The appropriate balance between efficiency and the fair distribution of resource allocation are not discussed here even though it is one important topic in public economics. In future research, a discussion of the fair distribution of resource allocation is needed.

Bibliography

- Arocena, P. (2008). Cost and quality gains from diversification and vertical integration in the electricity industry: A DEA approach. *Energy Economics*, 30 (1), 39-58.
- Aigner, D., Lovell C. A. K., and Schmidt P. (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics*, 6, 21-37.
- Arima, M. (2006a). The trends and problems of empirical studies concerning cultural economics. *Journal of Cultural Economics Japan*, 3-1, 11-16 (in Japanese).
- Arima, M. (2006b). The structure of the demand for art and culture focused on consumers' behavior: National Survey of Family Income and Expenditure, 1999. *Journal of Cultural Economics Japan*, 5-1, 49-60 (in Japanese).
- Arima, M. (2008). The structure of the demand for art and culture focused on consumers' behavior. *Journal of Research on Household Economics Japan*, 79, 13-29 (in Japanese).
- Arima, M. (2010). A cohort analysis for the structure of the demand for art and culture. Cultural Economics Japan Conference Proceedings, 58-59 (in Japanese).
- Arima. M, (2011). What are the driving forces for arts and culture related activities in Japan?, *Cultural Economics Japan Conference Proceedings*, 22-23 (in Japanese).
- Association of Public Theaters and Halls in Japan (2009). Survey Report about Introducing the Designated Manager System in Public Cultural Facilities, December (in Japanese).
- Battese, G. E. and Coelli, T. J. (1992). Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India. *Journal of Productivity Analysis*, 3(1/2), 153-169.
- Baumol, W. J., Panzar, J. C., and Willig, R. D. (1982). Contestable Markets and the Theory of Industry Structure, New York: Harcourt Brace Jovanovich.

- Bergstrom, T., Blume L., Varian H. (1986). On the private provision of public goods. *Journal* of *Public Economics*, 29, 25-50.
- Brooks, A. C., (1999). Nonprofit Firms in the Performing Arts, In Ginsburgh, V. A. (eds.), Handbook of Art and Culture Volume.1, (Chapter 15), Amsterdam: North-Holland.
- Coelli, T. J., (1996). A guide to DEAP version 2.1: a data envelopment analysis (computer) program. *Centre of Efficiency and Productivity Analysis Working Paper*, 96/08.
- Cooper, W. W., Seiford, L. M., and Tone, K. (2007). Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software, 2nd ed., New York: Springer.
- Cultural Policy Network (*Bunkaseisaku Network*) (eds.) (2004). What will change after the introduction of the designated manager system?, Tokyo: Suiyosha (in Japanese).
- Debreu, G. (1951). The Coefficient of Resource Utilization. Econometrica, 19 (3), 273-292.
- Dokko, J. K., (2009). Does the NEA Crowd Out Private Charitable Contributions to the Arts?, *National Tax Journal*, LXII (1), 57-75.
- Farell, M. J. (1957). The measurement of productive efficiency. Journal of the Royal Statistical Society, A CXX (3), 253-290.
- Fillipini, M. and Hunt, L. C. (2009). Energy demand and energy efficiency in the OECD countries: A stochastic demand frontier approach, Center for Energy Policy and Economics Swiss Federal Institutes of Technology, Working Paper No. 68.
- Fillipini, M. and Hunt, L. C. (2011). Energy demand and energy efficiency in the OECD countries: A stochastic demand frontier approach. *The Energy Journal*, 32 (2), 59-80.
- Globerman, S., and Book, S. H. (1974). Statistical cost functions for performing arts organizations. *Southern Economic Journal*, 40, 668-671.
- Goto, M. (2002). The panel data analysis for the measuring of the productive efficiency via stochastic frontier model: Measuring of the efficiency of the electric industry especially

electricity supply network section. *Journal of the Japan Society of Public Utility Economics*, 53 (3), 39-48 (in Japanese).

- Goto, M., and Inoue, T. (2012). Economic analysis of structural reforms of electricity industry: Investigation of cost structure of Japanese electricity. Central Research Institute of Electric Power Industry Research Report, Y11009. (in Japanese)
- Greene, W. (2005). Fixed and random effects in stochastic frontier models. *Journal of Productivity Analysis*, 23, 7-32.
- Halter, A. N., Carter, H. O., and Hocking, J. G. (1957). A note on the transcendental production function. *Journal of Farm Economics*, 39, 966-974.
- Harimaya, K. (2003). Measuring the cost efficiency of Japanese bank: A comparison between unconsolidated accounts and consolidated accounts. *Kaikeikensakenkyu*, 28, 201-215. (in Japanese)
- Hattori, T., Jamasb, T. and Pollitt, M. (2005). Electricity distribution in the UK and Japan: A comparative efficiency analysis 1985-1998, *Energy Journal*, 26 (2), 23-47.
- Hausman, J. A. (1978). Specification tests in econometrics. Econometrica, 46 (6), 1251-1271.
- Hayashi, T. (1997). *Project for public utility and deregulation*, Tokyo: Toyo Keizai (in Japanese).
- Honma, M. (1993). Economics of Philantholopy. Tokyo: Toyo Keizai (in Japanese).

International Energy Agency (2011). Energy of balances OECD countries 2011, International Energy Agency. (online) (http://www.oecd-ilibrary.org/energy-balances-of-non-oecd-countries-2011_5kgi41rbp9lq.pdf;jsessionid=38qgx9ieswv2s.x-oecd-live-03?contentType=%2fns%2fStatisticalPublication%2c%2fns%2fBook%2c%2fns%2fOECD Book&itemId=%2fcontent%2fbook%2fenergy bal_non-oecd-2011en&mimeType=application%2fpdf&containerItemId=%2fcontent%2fserial%2f19962843en&accessItemIds=%2fcontent%2fserial%2f19962843%2c) James, E. (1983). How nonprofits grow: A model. *Journal of Policy Analysis and Management*, 2 (3), 350-366.

Japan Foundation for Regional Art-Activities (2006). *The condition of introducing designated* manager system into Japanese local government: Survey of all over Japan and case studies: Survey and study report in November, 2006. (online) (in Japanese) (http://www.jafra.or.jp/j/library/investigation/018/data/18_1.pdf)

- Japan Foundation for Regional Art-Activities (2007). The actual situation of introducing designated manager system into Japanese local government: *Survey of all over Japan and case studies: Survey and study report* in March, 2007. (online) (in Japanese) (<u>http://www.jafra.or.jp/j/library/investigation/019/data/19_13.pdf</u>)
- Jaume, P. J. (2000). Partitioning input cost efficiency into its allocative and technical components: An empirical DEA application to hospitals. *Socio-Economic Planning Sciences*, 34, 199-218.
- Jorgenson, D. W. (1986). Econometric methods for modeling producer behavior. In Griliches, Z. D., and Intriligator, M. D. (eds.), *Handbook of Econometrics Volume 3*, (Chapter 31), Amsterdam: North-Holland.
- Kaserman, D. and Mayo J. W. (1991). The measurement of vertical economics and efficient structure of the electric utility industry. *Journal of Industrial Economics*, 39 (5), 483-502.
- Kinugasa, T. (2011). An Estimation of the competitiveness of market after deregulation; An analysis using the translog function for Japanese electricity industry. *the 68th Japan Economic Policy Association Conference. Proceeding.* (in Japanese) (<u>http://www.komazawa-u.ac.jp/files/880/p37.pdf</u>)
- Kitasaka, S. (2011a). The cost functions of national universities in Japan: Simultaneous estimation using a translog cost share model. Working Paper, Faculty of Economics, Doshisha University, Japan. (in Japanese)
- Kitasaka, S. (2011b). The cost function of private universities in Japan: Simultaneous estimation using a translog cost share model. Working Paper, Faculty of Economics, Doshisha University, Japan. (in Japanese)

- Kobayashi, M. (2006). *Designated manager system: Who does support the cultural publicity?*, Tokyo: Jiji Press. (in Japanese)
- Kopp, R. J., and Diewert, W. E. (1982). The decomposition of frontier cost function deviations into measures of technical and allocative efficiency. *Journal of Econometrics*, 19, 319-331.
- Kuwabara, T., and Ida, T. (2000). The panel data analysis of the Japanese electric power industry. *Kouekijigyoukenkyu*, 52 (2), 71-82. (in Japanese)
- Kuan, J. (2001). The phantom profits of the opera: Nonprofit ownership in the arts as a makebuy decision. *Journal of Law, Economics, and Organization*, 17 (2), 507-520.
- Kumbhakar, S. C., and Lovell, C. A. K. (2000). *Stochastic frontier analysis*, Cambridge, UK: Cambridge University Press.
- Last, A., and Wetzel, H. (2010). The efficiency of German public theaters: A stochastic frontier analysis approach. *Journal of Cultural Economics*, 34, 89-110.
- Lee, Y., (2010). The impact of deregulation on stock market efficiency, *International Journal* of Business and Finance Research, 4 (2), 165-76.
- Maki, A. (2001). An Introduction to Applied Econometrics, Tokyo: Nippon-Hyoron-sha. (in Japanese)
- Meeusen, W., and van den Broeck J. (1977). Efficiency estimation from Cobb-Douglas production function with composed error. *International Economic Review*, 18, 435-444.
- Minister of Economy, Trade and Industry (2011). Material 3: Discussion Points of the Calculations for Electricity Charges, constructed by Heisei 23 nen 12 gatsu Denkiryoukinseido Unyou no Minaoshi nikakaru Yushikisyakaigi Jimukyoku. (<u>http://www.meti.go.jp/committee/kenkyukai/energy/denkiryoukin/003 03 01.pdf</u>) (<u>http://www.meti.go.jp/committee/kenkyukai/energy/denkiryoukin/003 03 02.pdf</u>)
- Nakagawa, I. (2001). The Japanese local government's cultural policy for the times of a decentralization, Tokyo: Keiso Shobo. (in Japanese)

- Nakagawa, I. (2004). The Japanese local government's cultural policy for the times of a decentralization, Tokyo: Keiso Shobo. (in Japanese)
- Nakagawa, I. (2005). A prospective on the Designated Manager System and public cultural facilities. *The Journal of Cultural Economics Japan*, 4 (4), 5-10.
- Nakagawa, I. and Matsumoto, S. (2007). *How is the designated managers now?*. Tokyo: Suiyosha. (in Japanese)
- Nakaya, K. (ed.) (2005). An assessment of the policies for public halls (Koukyou Houru no Seisakuhyouka), Tokyo: Keio University Press. (in Japanese)
- Nakayama, N. (2002). Measuring the economic efficiency of the Japanese water service industries. *Japanese Economic Study*, 45, 23-40. (in Japanese)
- Nemoto, J. and Goto, M. (2006). Measurement of technical and allocative efficiencies using a CES cost frontier: A benchmarking study of Japanese transmission-distribution electricity, *Empirical Economics*, 31, 31-48.
- O'Donnell, C. J., and Nguyen, K. (2012). An econometric approach to estimating support prices and measures of productivity change in public hospitals. *Journal of Productivity Analysis.*
- Pesaran, M. H., and Schmidt. P. (eds.) (1997). Handbook of Applied Economics, Vol. 2, Microeconomics, Oxford: Blackwell Publishers, 81-166.
- Reichmann, G. (2004). Measuring university library efficiency using data envelopment analysis. *Libli*, 54, 136-146.
- Sakai, H., and Takahashi, Y., (2013). Ten years after bus deregulation in Japan: An analysis of institutional changes and cost efficiency, *Research in Transportation Economics*, 39, 215-25.
- Seim, K., and Waldfogel, J., (2013). Public monopoly and economic efficiency: evidence from the Pennsylvania liquor control board's entry decisions, *American Economic Review*, 103

(2), 831-62.

- Schmitz, L. (2010). The giving trap: Cultural taxation and its role in the reduction of private funding for the arts, Paper presented at the International Conference of Association for Cultural Economics International held at Copenhagen Business School, Denmark.
- Steinberg, R. (1986). The revealed objective functions of nonprofit firms. Rand Journal of Economics, 17 (4), 508-526.
- Taalas, M. (1997). Generalised cost functions for producers of performing arts: Allocative inefficiencies and scale economies in theatres. *Journal of Cultural Economics*. 21 (19), 335-353.
- Tachiki, S. (1999). *Contemporary Japanese public halls and theater*, Tokyo: Sojinsha. (in Japanese)
- Tamura, H. (2002). Assessment for the Japanese public libraries and the data envelopment analysis. *Journal of Japan Society of Library and Information Science*, 47 (4), 145-162. (in Japanese)
- Taniguchi, M. (2011). Measuring the productive efficiency of the designated manager system for the Japanese public halls. Kumamoto University, Japan.
- Taniguchi, M. (2013a). The Impact of Liberalization on the Production of Electricity in Japan, Keio/Kyoto Joined Global Center of Excellence Program, Raising Market Quality-Integrated Design of Market Infrastructure, DP2012-027.
- Taniguchi, M. (2013b). The Impact of Liberalization on the Production of Electricity in Japan, the Proceedings of the International Conference on Applied Economics (ICOAE) 2013, 27-29 June 2013, Istanbul, 712-721.
- Taniguchi, M. (2014a). The Impact of Liberalization on the Production of Electricity in Japan: Stochastic Frontier Analysis, Open Journal of Applied Science, 4 (4), 155-167.

Taniguchi, M. (2014b). The Impact of Local Government Cultural Policies on the Sales of

Tickets for Private Music Concerts, Keio Economic Studies, 50, 51-65.

- The Association of Public Theaters and Halls in Japan (2003 2008). *The membership list of public halls in Japan*, Tokyo: The Association of Public Theaters and Halls in Japan. (in Japanese)
- Throsby, C. D., and Withers, G. A. (1979). *The economics of performing arts*, New York: St. Martins.
- Tsutsui, M. (2000). Comparison of intertemporal technical efficiency by sector among Japanese and US electric utilities; the application of Malmquist index calculated by DEA. Central Research Institute of Electric Power Industry Research Report, Y99013. (in Japanese)
- West, E. G. (1987). Nonprofit versus profit firms in the performing arts. Journal of Cultural Economics, 11 (2), 37-48.
- Yamaguchi, S. (2007). The results and issues of the electricity liberalizations in Japan: A comparison of Japan to Europe and the US, Issue Brief, No.595 (in Japanese)
- Yamashita, K. Akai, N. and Sato, M. (2002). Incentive effect lying the system which tax revenue are allocated to local governments: Verification of the soft budget problem via frontier cost function. *Financial Review*, 61, 120-145. (in Japanese)
- Zieba, M. (2009). Full-income and price elasticities of demand for German public theatre. Journal of Cultural Economics, 33 (2), 85-108.
- Zieba, M. (2011). Determinants of Demand for Theatre Tickets in Austria and Switzerland. Austrian Journal of Statistics, 40 (3), 209-219.

(Website)

The Federation of Electric Power Companies of Japan (<u>http://www.fepc.or.jp</u>) Tokyo Electric Power Company (<u>http://www.tepco.co.jp</u>)