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Structural and Regional Characteristics and Cost Efficiencies in the Local Public Health Insurance System: Empirical Evidence from the Japanese National Health Insurance System

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Abstract

In this study, I use panel data from municipal Japanese National Health Insurance (JNHI) insurers to estimate their financial efficiency scores using nonparametric methods and to estimate the causal effects of structural and regional characteristics on the efficiency scores consistently using econometric methods. The major findings of this study are as follows. First, the estimated efficiency scores imply that many JNHI insurers have serious financial inefficiencies, and that total cost efficiency (economic efficiency) is strongly and positively correlated with allocative efficiency. Second, the empirical results of the effects of various factors on efficiency scores indicate that the two major policy reforms for health care systems for the elderly in 2008 contribute strongly to the improvement of JNHI insurers' finances. Third, the subsidy from a prefectural government positively affects efficiencies, but subsidies from central and municipal governments have an adverse effect. Fourth, contributions to health care systems for the elderly still have an adverse effect on JNHI finances.

Keywords

cost efficiencies, Japanese National Health Insurance system, data envelopment analysis, panel data analysis, Japan

1. Introduction (Note 1)

The development of health insurance systems has contributed to improvements in health, quality of life, and life expectancy worldwide. In Japan, the revision of the National Health Insurance Act in 1958 created a universal public health insurance system by requiring uninsured individuals to become insured through the municipality-based Japanese National Health Insurance (JNHI) system. The Japanese universal health insurance system has enabled Japanese citizens to access high-quality health care services at affordable prices. As a result, health levels and life expectancy in Japan quickly became the highest in the world (Ikeda et al., 2011; Ikegami et al., 2011).

Notwithstanding the previous excellent performance of Japan's universal health insurance system, its present finances and future financial sustainability are threatened by demographic and economic factors. The Japanese Ministry of Health, Labour, and Welfare (MHLW) (2016) reported that 967 JNHI insurers (56.4 percent of the total) experienced budget deficits in 2014. The deficits were chronic for 569 of those insurers; in 2014, the total deficit of JNHI insurers was approximately 359 billion yen. The tenuousness of the present situation can be traced to a number of factors including the aging population of enrolled members, increases in the number of low-income members, an increase in the number of small-scale insurers, decreases in premium payment rates, and regional disparities in health care expenditures and premiums (Yamada, 1997; Kishida, 2002; Izumida, 2003; National Health Insurance Division, Health Insurance Bureau, and the Ministry of Health, Labour, and Welfare, 2006; Yuda, 2010). In addition, approximately half the expenses of the JNHI system have been financed by government subsidies at central and local levels. These subsidies have contributed to the stability of the insurers' finances, but also provided little incentive to improve their operating Cost Efficiency (CE); this is a soft budget problem (Tajika & Yui, 1999; Suzuki, 2001; Yoshida & Kawamura, 2008; Yuda, 2016). Moreover, the moral hazard for both patients (e.g., more frequent visits to medical institutions) and care providers (e.g., extremely supplier-induced demand) leads to excessive expenditures that may exacerbate insurers' fiscal condition (Zweifel & Manning, 2000; McGuire, 2000; Chandra, Cutler, & Song, 2012; Dranove, 2012). With the public finances of JNHI insurers on track toward insolvency, the MHLW is currently attempting to design policy reforms to avert more serious systemic problems.

This study aims to explore how these various structural and regional factors currently experienced by the JNHI insurers affect their finances in terms of their CEs. The results of this study have important policy implications for future reforms of the JNHI system. As Japan is at the global forefront of population aging, the Japanese experience may provide important lessons for other countries with aging populations that have introduced universal health insurance systems. However, these Japanese studies have two crucial analytical problems, which have resulted in serious misunderstandings. First, the cost functions estimated in all of the previous Japanese studies, except for those of Yuda (2010, 2016), do not include both the output variables and factor prices. Thus, their equations are not based on economic theory and the results are inconsistent because of a serious omitted variables bias problem. Second, Yuda (2010, 2016) imposes several restrictions on the background theoretical and empirical models because of technical problems. However, these restrictions do not necessarily ensure consistent causal effects. To overcome these analytical problems, I employ a more general efficiency approach as with Bates, Mukherjee and Santerre (2010). Specifically, I first measure each JNHI insurer's CE scores using Data Envelopment Analysis (DEA). I then estimate the causal effects of the various structural and regional factors on CEs using the Tobit model. In addition, I use insurer-level panel data to obtain more general and consistent estimators than those of Bates, Mukherjee and Santerre (2010) and Yuda (2016), as mentioned in Section 2.1.

The major findings of this study are as follows. First, estimated efficiency scores imply that many JNHI insurers have serious financial inefficiencies, and that total CE (economic efficiency) is strongly and positively correlated with Allocative Efficiency (AE). Second, the empirical results of the effects of various factors on efficiency scores indicate that the two major policy reforms for the health care system for the elderly in 2008 contributed strongly to the improvement of JNHI insurers' finances. Third, the subsidy from a prefectural government positively affects efficiencies, but subsidies from central and municipal governments have an adverse effect. Fourth, the contributions to health care systems for the elderly still have an adverse effect on JNHI finances, as found by Yuda (2016).

The remainder of the paper is organized as follows. In the next section, I review the two earlier studies most closely related to this study and present my analytical background. In Section 3, I present details of the data. In Section 4, I present empirical results. In Section 5, I conclude.

2. Analytical Frameworks

2.1 Closely Related Previous Studies and the Empirical Strategy

In this subsection, I review two closely related previous studies: Bates, Mukherjee and Santerre (2010) and Yuda (2016).

Yuda (2016) employs stochastic frontier models to examine the sources of CEs in the JNHI insurance system using municipal insurers' panel data. Yuda (2016) finds that adverse effects on efficiency are mainly associated with the aging of the insured population, soft budget constraints caused by government subsidies, and insurer contributions to health care systems for the elderly. However, Yuda (2016) imposes several restrictions on the background theoretical and empirical models because of the technical problem of nonconvergence of some log-likelihood functions. These restrictions do not necessarily ensure consistent causal effects, and in fact, all estimated CEs and AEs, theoretically defined as (0,1), greatly exceed one. The first specific restriction is to assume a Cobb-Douglas function, which is one of the special forms of a constant elasticity of substitution function. Second, Yuda (2016) also assumes that the inefficiency term is distributed as a half-normal distribution. Because the results sometimes depend on the assumptions underlying the functional specification of the distribution of the inefficiency term, it is unclear whether the results are robust. Third, the empirical models used in Yuda (2016) are the pooled and random effects models, despite using insurer-level panel data. The empirical results would be biased because the pooled estimation cannot consider time series variations among insurers and because the random effects assumption that unobserved individual heterogeneity is not correlated with the independent variables is generally too restrictive.

One of the solutions for the first and second problems is to use the DEA method to estimate efficiency scores, as with Bates, Mukherjee and Santerre (2010). DEA involves the use of linear programing methods to construct a nonparametric piecewise frontier over the data and calculate efficiencies relative to this frontier (Coelli, 1996). Bates, Mukherjee and Santerre (2010) empirically examine the impact of health insurance on the Technical Efficiency (TE) of health production by using data across the metropolitan statistics area and find that insurance coverage generates inefficiency, but that the efficiency loss appears to be relatively small in the extensive margin. However, they have the same problem as Yuda (2016) because their estimates are also obtained using pooled and random effects models. That is, the TE scores in Bates, Mukherjee and Santerre (2010) would be biased because they did not consider within variations, and this bias would more seriously affect the empirical results in the second-stage Tobit analysis. A simple solution to this problem is to employ the Fixed Effects (FE) model, which allows unobserved individual heterogeneity to be correlated with the independent variables. Unfortunately, although Charnes et al. (1985) propose a panel DEA model, the FE Tobit model proposed by Heckman and McCurdy (1980) and Honoré (1992) has poor empirical performance because of the computational issue. Instead, I attempt to use First-Differenced (FD) data to remove the FE.

Moreover, I ease the following three analytical restrictions in Bates, Mukherjee and Santerre (2010) and Yuda (2016) to obtain more general and consistent estimators. First, I employ a multiple outputs and inputs model for measuring efficiency scores. These two studies use a one-output and multi-inputs model, but the multiple outputs and inputs model is more appropriate for providing better estimations because the health insurance system provides many outcomes, including health promotion, risk dispersion, and self-management. Second, I assume Variable Returns to Scale (VRS) in the model when estimating the efficiency scores using DEA. Although Bates, Mukherjee and Santerre (2010) use a Constant Returns to Scale (CRS) model, the CRS assumption is appropriate only when all insurers are operating at an optimal scale. However, imperfect competition, government regulations, and constraints on finance may cause a firm to operate at a suboptimal scale. Their results assumed the CRS specification results in measures of TE confounded by Scale Efficiencies (SEs), but assuming the VRS specification permits the calculation of TE devoid of these SE effects. Third, Bates, Mukherjee and Santerre (2010) only focus on TE, which reflects the ability of an insurer to obtain maximal output from a given set of inputs and Yuda (2016) only estimates the causal effects on CE (Note 2). However, CE can be decomposed into TE and AE. A firm's AE reflects the ability to use its inputs in optimal proportions, given their respective prices. In terms of health insurance finance, the TE represents factors not attributable to insurers and the AE those attributable to insurers. Because they are different characteristics, this decomposition is important for obtaining useful policy implications for future policy reforms of the system.

The remainder of this section presents the specific empirical models used in this study.

2.2 Estimating Efficiencies by the DEA

For the case of VRS, cost minimization of the input-oriented DEA model is conducted to first obtain TEs (Coelli et al., 2005).

$$\min_{\theta,\boldsymbol{\lambda}} \quad \theta$$
$$\text{s.t.} \quad -\mathbf{q_i} + \mathbf{Q}\boldsymbol{\lambda} \geq \mathbf{0}$$

$$\theta \mathbf{x_i} - \mathbf{X\lambda} \geq \mathbf{0}$$
$$\boldsymbol{\lambda} \geq \mathbf{0},$$

where θ is a scalar, which represents insurer i's TE score (Farrell, 1957). The variables **q** and **x** are the column vector of insurer i's M outputs and N inputs, respectively. The $M \times I$ output matrix **Q** and $N \times I$ input matrix **X** represent the data for all I insurers. The parameter $\boldsymbol{\lambda}$ is a $I \times 1$ vector of constants. This linear programing problem is solved I times, once for each insurer in the sample. A value of $\theta_i = TE_i$ is obtained for each insurer. The next step requires the solutions of the following cost minimization DEA:

$$\min_{\boldsymbol{\lambda}, \mathbf{x_i^*}} \quad \mathbf{w_i'x_i^*}$$
$$\text{s.t.} \quad -\mathbf{q_i} + \mathbf{Q\lambda} \geq \mathbf{0}$$
$$\mathbf{x_i^*} - \mathbf{X\lambda} \geq \mathbf{0}$$
$$\mathbf{I1'\lambda} = 1$$
$$\boldsymbol{\lambda} \geq \mathbf{0},$$

where $\mathbf{w_i}$ is a $N \times 1$ vector of input prices for the ith insurer and $\mathbf{x^*_i}$ is the cost-minimizing vector of input quantities for the ith insurer given the input price $\mathbf{w_i}$ and the output levels $\mathbf{q_i}$; and $\mathbf{I1'\lambda} = 1$ is the convexity constraint. Then, the CE of insurer i is defined as the ratio of minimum cost to observed cost:

$$CE_i = \mathbf{w_i'x_i^*}/\mathbf{w_i'x_i} \tag{1}$$

The AE is also calculated as

$$AE_i = CE_i/TE_i \tag{2}$$

These three measures of TE, AE, and CE can take values ranging from 0 to 1, where a value of 1 indicates full efficiency.

2.3 Closely Related Previous Studies and the Empirical Strategy

To examine the causal effects of the efficiency scores, I first consider the following simple linear equations.

$$CE_{it} = \alpha_0 + \sum_{j=1}^{J} \ln(z_{j,it})\alpha_j + e_{CE,i} + u_{CE,it} \tag{3a}$$

$$TE_{it} = \beta_0 + \sum_{j=1}^{J} \ln(z_{j,it})\beta_j + e_{TE,i} + u_{TE,it} \tag{3b}$$

$$AE_{it} = \gamma_0 + \sum_{j=1}^{J} \ln(z_{j,it})\gamma_j + e_{AE,i} + u_{AE,it} \tag{3c}$$

where $\ln(z_{it})$ includes the logarithms of the control variables representing demographic, financial, and market conditions of insurer i in year t. Here, e is the individual-insurer effect and u is an error term. Parameters in these equations take on negative values when the control variables negatively affect an insurer's finances.

To eliminate the insurer effect by first-differencing, the models are:

$$\Delta CE_{it} = \sum_{j=1}^{J} \Delta \ln(z_{j,it})\alpha_j + \Delta u_{CE,it} \tag{4a}$$

$$\Delta TE_{it} = \sum_{j=1}^{J} \Delta \ln(z_{j,it})\beta_j + \Delta u_{TE,it} \tag{4b}$$

$$\Delta AE_{it} = \sum_{j=1}^{J} \Delta \ln(z_{j,it})\gamma_j + \Delta u_{AE,it} \tag{4c}$$

where ΔTE, ΔAE, and ΔCE represent efficiency scores obtained from DEA using the FD data, and $\Delta\ln(z)$ represents the first-differenced variables. When a constant term, $\alpha_{2010}, \beta_{2010}$, and γ_{2010}, is added to the equations, it can be interpreted as the annual effect of, e.g., policy reforms during the study period.

$$\Delta CE_{it} = \sum_{j=1}^{J} \Delta \ln(z_{j,it})\alpha_j + \alpha_{2010} + \Delta u_{CE,it} \tag{5a}$$

$$\Delta TE_{it} = \sum_{j=1}^{J} \Delta \ln(z_{j,it})\beta_j + \beta_{2010} + \Delta u_{TE,it} \tag{5b}$$

$$\Delta AE_{it} = \sum_{j=1}^{J} \Delta \ln(z_{j,it})\gamma_j + \gamma_{2010} + \Delta u_{AE,it} \tag{5c}$$

Specifically, the equations particularly capture when two major reforms are introduced to the health insurance systems for the elderly. The first reform is the introduction of a reinsurance scheme at the national level to cover medical expenditures for elderly aged 65 to 74 years. Although the JNHI insurers were reimbursed for their medical expenditure before April 2008, the reinsurance scheme now provides financial support for JNHI insurers. The second reform was the introduction of the Long-life Health Care System (LHCS), a special health insurance system for those aged 75 years and over. Because most of those aged 75 years and over had been exempt from paying insurance premiums because of their low income, their medical expenditure was reimbursed by the public health insurance system including the JNHI under the previous Elderly Health Care System (EHCS) from February 1983 to March 2007. After April 2008, their premium contribution covered 10 percent of their medical expenditure. Since these drastic reforms of the health care systems for the elderly reduce the financial burden on the JNHI system, they positively affect the finances of the JNHI (Note 3).

3. Data and Descriptive Statistics

Data on municipal insurers are taken from the Japanese MHLW's *Annual Report on National Health Insurance Activity* for 2005 and 2010. These statistics survey the details of insurer characteristics, including enrollee structure, accounting measures and insurance benefits. I merge these details with several variables at the municipality level taken from other sources of public statistics to produce two-year insurers' panel data, which is the same sample as that of Yuda (2016). Table 1 reports the summary statistics of the variables and their sources.

During the estimation process, Cummins and Weiss (2011) note that careful definition of outputs and inputs and their corresponding factor prices is key to reliable efficiency estimation and is consistent with economic insurance theory. I modify their approach because the JNHI system is a public health insurance system in which the insurers are municipalities operating in a quasi-market (Le Grand, 2007). The two output variables **q** include the net revenue of the JNHI special account maintained by the municipal government and life expectancy in the insuring municipality.

Table 1. Descriptive Statistics

Variables (1)	Mean	SD	Min	Max	Source(4)
Endogenous variables					
Net revenue (million yen)	8.071	139.686	-6746.042	1143.406	[1]
Life expectancy(2) (years)	82.530	0.820	79.400	85.050	[2]
Input variables					
Number of administrative staff	10.146	22.129	0.000	573.500	[1]
Number of medical institutions	102.393	294.446	0.000	5769.000	[1], [3]
Number of physicians	215.988	663.685	1.000	11349.00	[1], [4]
Equity capital (100 million yen)	-0.002	0.076	-3.960	0.000	[1]
Corresponding factor prices (million yen)					
Administrative cost per staff	0.851	0.624	0.000	15.367	[1]
Health insurance reimbursement per medical institution	6.038	2.225	0.245	36.769	[1], [3]
Health insurance reimbursement per physician	4.646	3.146	0.078	49.122	[1], [4]
Debt expenditure	3226.783	102.943	1.000	3915.659	[1]
Control variables					
Number of insured (thousand people)	21.197	50.332	0.097	941.021	[1]
Ratio of fiscal adjustment subsidy to revenue (%)	0.773	0.952	0.000	10.057	[1]
Ratio of prefectural government subsidy to revenue (%)	0.442	0.504	0.007	3.434	[1]
Ratio of transfers from municipality to revenue (%)	1.064	1.568	0.007	15.585	[1]
Ratio of nonstatutory transfer to municipality transfer (%)	17.367	21.973	0.000	88.555	[1]
Ratio of joint insurance grant to revenue (%)	0.939	1.375	0.003	11.681	[1]
Premium payment rate (%)	91.772	4.049	71.944	100.000	[1]
Contribution to the health care systems for the elderly (million yen)	113.192	292.117	0.419	6710.767	[1]
Physician density (per 1,000 residents) (3)	1.544	1.602	0.104	30.028	[4], [5]
Dentist density (per 1,000 residents) (3)	0.658	0.831	0.043	33.068	[4], [5]
Hospital bed density (per 1,000 residents) (3)	10.489	8.415	0.022	106.025	[4], [5]
Number of observations			3410		

Note. (1) All *yen* are adjusted to 2010 prices using the consumer price index. Variables with minimum values less than zero are adjusted to allow for log transformation.

(2) Average life expectancy between females and males.

(3) Numerical values except for the survey year are calculated by linear interpolation.

(4) Sources are as follows: [1] *Annual Report on the National Health Insurance Activity* (2005, 2010), the Ministry of Health, Labour, and Welfare, [2] *Municipal Life Tables* (2005, 2010), the Ministry of Health, Labour, and Welfare, [3] *Survey of Medical Institutions* (2005, 2010), the Ministry of Health, Labour, and Welfare, [4] *Survey of Physicians, Dentists and Pharmacists* (2004, 2006, 2010), the Ministry of Health, Labour, and Welfare, and [5] *Population Census* (2005, 2010), Statistical Bureau, the Ministry of Internal Affairs and Communications.

Net revenue is the foremost indicator of JNHI's finances and its selection is supported by the economic theory of insurance (Cummins & Weiss, 2011). Life expectancy is commonly used as a measure of health outcomes at the country or regional level (Note 4). The mean of the net revenue of JNHI special accounts is approximately 8.1 million yen, with negative values exhibited for about 30 percent of the observations, and the mean life expectancy is 82.5 years.

Input variables **x** are typically classified into three principal groups: labor, capital, and business services and materials (Cummins & Weiss, 2011). Following Yuda (2016), I focus on labor and capital as input variables because the business services and materials provided by public health insurance providers are difficult to define and quantify. As labor inputs, I use the size of the administrative staff of municipal insurers and the number of medical institutions, as well as the number of physicians. In Japan, physicians serving in medical institutions are not independent economic agents but rather function as production inputs of the institutions. Insurers reimburse medical institutions for the cost of physician services instead of issuing payments directly to individual physicians (Hashimoto & Izumida, 2016, p.13) and medical institutions accounted for approximately 67 percent of the total expenditures of the JNHI insurance system in 2014 (MHLW, 2016). To proxy the capital inputs, I follow the common practice in efficiency analysis and use an insurer's equity capital (Cummins & Weiss, 2011). The factor price for administrative labor input is the cost per staff member. The factor prices for physicians and medical institutions are their respective insurance reimbursement rates.

For capital, the expected market return on equity capital is the ideal measure of cost (Cummins & Weiss, 2011). However, because JNHI insurers do not issue dividend-yielding shares, I use the cost of their debt as the proxy. Inputs per insurer are, on average, 10.1 administrative staff, 102.4 medical institutions, and 216.0 physicians. Mean annual costs are 0.85 million yen per administrative staff member, 6.0 million yen per medical institution and 4.6 million yen per physician. The mean debt expenditure is 3.2 billion yen per year.

Table 1 also includes the control variables **z** that may affect efficiency in JNHI insurers as proposed by the National Health Insurance Division of the Health Insurance Bureau of the MHLW (2006) and previous Japanese studies. They are grouped into three categories pertaining to the demographic structure of the insured, financial elements of the JNHI system and conditions in the market for medical care. A key demographic measure (Note 5) is the number of insured and its square, which captures a scale effect. Larger insured pools contribute to financial stability and are thus expected to have a positive effect on efficiency. Key financial elements of the JNHI system include: five types of government subsidies, the premium payment rate and the financial contribution to the health care systems for the elderly. Approximately half of the expenses of the JNHI system have been financed by government subsidies at central and local levels. These subsidies have contributed to stability in the insurers' finances but have also led to soft budget problems (Tajika & Yui, 1999; Suzuki, 2001; Yoshida & Kawamura, 2008; Yuda, 2016). The subsidies are designed to achieve differing goals. The fiscal adjustment subsidy and the prefectural government subsidy reduce fiscal imbalances among municipal insurers. The joint insurance grant is a reinsurance benefit for high health care expenditures. Transfers from a municipality's general account are classified into two types: statutory and nonstatutory. The latter transfer is intended to stabilize the finances of the insurers, whereas a nonstatutory transfer is mainly aimed at covering deficits. The nonstatutory transfer is especially contrary to the principle of insurance because the financial resources for this transfer come from local taxes. In other words, this subsidy is an actual income transfer from local taxpayers to people insured by the JNHI. This variable is a proxy for the seriousness of the soft budget problem. The premium payment rate measures payments collected relative to amounts due. A lower premium payment rate indicates failure in collection, which has a negative effect on the insurer's finances. Another factor that impinges on the finances of the JNHI insurers is their contribution to the EHCS or LHCS. The rapid and continued aging of Japan's population has caused medical benefits payable on behalf of the elderly to increase, which has worsened insurers' already poor finances. In fact, this burden has gradually increased in recent years and has directly led to serious financial problems for public health insurers (MHLW, 2016). Variables reflecting conditions in the market for medical care include the densities of physicians, dentists, and hospital beds expressed per 1,000 residents. Although an increase in these densities improves an insured person's access to medical care, payouts of health care benefits may also increase because of the incentive to both demand and supply unnecessary treatments created by the insurance system, which is a moral hazard affecting both patients and providers.

4. Empirical Results (Note 6)

4.1 Estimation Results of Efficiency Scores

Table 2 and Figure 1 summarize the efficiency scores obtained by DEA (Note 7). The mean and standard deviation of CE are 0.158 and 0.168, respectively, which indicates that there are many financially inefficient insurers. The mean and standard deviation of TE are 0.862 and 0.050, respectively. In contrast, the mean of AE is 0.178, which is one-fifth of that of TE, and the standard deviation is 0.182, which is bigger than that of TE. The correlation coefficient between CE and AE is positive and strong (0.998) which is larger than that between CE and TE (0.524) (Note 8). This tendency is consistent with Yuda (2016) and implies that the key to improving the finances of the JNHI insurers is to introduce an effective measure to improve AE.

Table 2. Distributions of Efficiency Scores

Efficiency	TE	AE	CE
Mean	0.572	0.011	0.006
Std. dvi	0.109	0.024	0.024
Min	0.196	0.000	0.000
Max	1.000	1.000	1.000
Number of observations		1705	

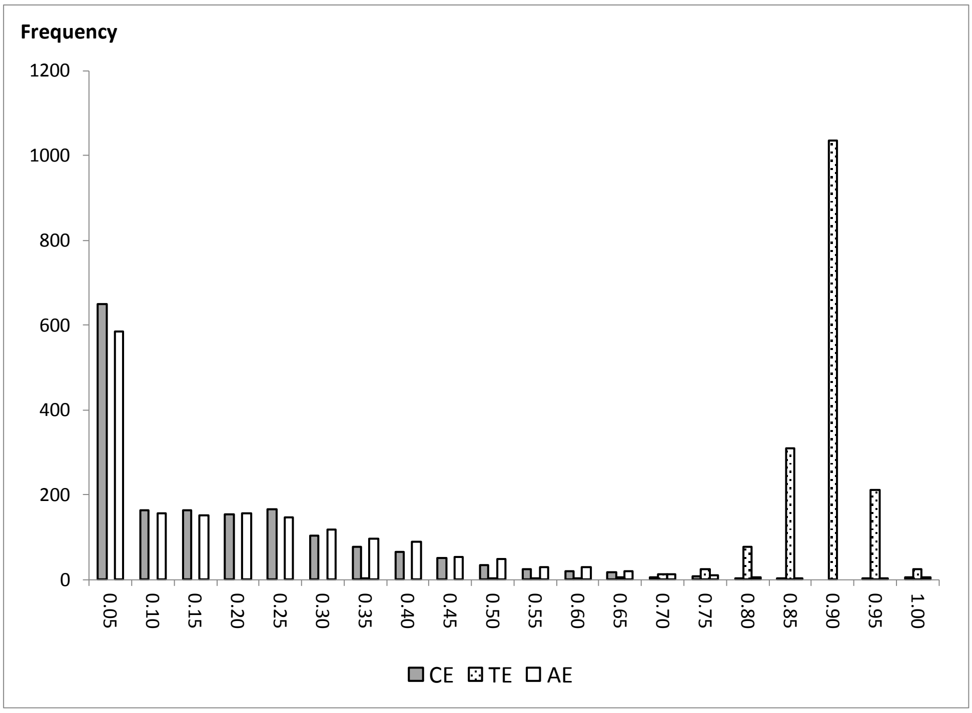

Figure 1. Distributions of Efficiency Scores

Table 3. Empirical Results of the Effects on Cost Efficiency

Method	Tobit	OLS	Tobit	OLS
Number of insured	-0.537***	-0.537***	-0.424***	-0.424***
	(0.112)	(0.112)	(0.103)	(0.102)
Squared number of the insured	-0.022	-0.022	0.016	0.016
	(0.030)	(0.030)	(0.025)	(0.025)
Fiscal adjustment subsidy	-0.046***	-0.046***	-0.021**	-0.021**
	(0.009)	(0.009)	(0.008)	(0.008)
Prefectural government subsidy	0.132***	0.133***	0.005	0.005
	(0.024)	(0.024)	(0.024)	(0.024)

Transfers from municipality	-0.037**	-0.037**	-0.012	-0.012
	(0.017)	(0.017)	(0.016)	(0.016)
Nonstatutory transfer	0.010***	0.010***	-0.002	-0.002
	(0.004)	(0.004)	(0.003)	(0.003)
Joint insurance grant	0.036***	0.036***	0.000	0.000
	(0.005)	(0.005)	(0.005)	(0.005)
Premium payment rate	-0.007	-0.007	0.007	0.007
	(0.009)	(0.009)	(0.008)	(0.008)
Contribution to the health care systems for the elderly	-0.055***	-0.055***	0.001	0.001
	(0.010)	(0.010)	(0.010)	(0.010)
Physician density	0.021	0.021	-0.029*	-0.029*
	(0.016)	(0.016)	(0.015)	(0.015)
Dentist density	-0.044***	-0.044***	-0.012*	-0.012*
	(0.007)	(0.007)	(0.007)	(0.007)
Hospital beds density	-0.006	-0.006	0.003	0.003
	(0.009)	(0.009)	(0.009)	(0.009)
Constant			0.138***	0.138***
			(0.010)	(0.010)
Standard error of the regression	0.174***		0.165***	
	(0.004)		(0.004)	
Number of observations	1705	1705	1705	1705
Log likelihood	559.483	566.119	646.159	653.012
R-squared	N.A.	0.434	-0.045	0.032

Note. ***, **, and * represent statistical significance at the 1, 5, and 10 percent levels. Robust standard errors are in parentheses.

4.2 Empirical Results of Causal Effects on Efficiencies

Tables 3-5 show the estimation results for the Tobit and Ordinary Least Squares (OLS) models using the FD data. First, the results for Tobit models are quite similar to those of OLS. Second, the coefficients of a constant term that captures a yearly effect are statistically and significantly positive. In particular, the coefficients of that constant term are larger than those of other control variables, and those of control variables in the models with a year effect approach zero compared with those without a year effect. These results imply that the introduction of the two major health insurance reforms for the elderly contributed to improving the efficiency of JNHI finances.

Table 3 shows the results of the effects on CE. The coefficients of the number of insured, fiscal adjustment subsidy and dentist density are significantly negative in the models with and without a year effect. These results intuitively contradict the economic insurance theory that an increase of insurer scale adversely influences CE. However, as shown in Appendix D, CE scores of city insurers are lower than those of rural insurers. Therefore, this result must reflect fundamental structural differences reflected in the city scale.

The significant negative effect of the fiscal adjustment subsidy on CE implies that insurers are oversubsidized for differences in fiscal status, which means that this subsidy creates a soft budget problem. The significant negative effect of dentist density would be caused by patients' overutilization, exacerbated by supplier-induced demand caused by the fierce competition in the dental care market in Japan. In the models without a year effect, the coefficients of transfers from municipal governments and contributions to the health care systems for the elderly are significantly negative. The adverse effect of transfers from municipal governments on CE also implies the existence of the soft budget problem. The positive effect of contributions to the health care systems for the elderly demonstrates that efficiency in the health care systems for the elderly is compromised, which and contributes to the deterioration of JNHI finances. In addition, prefectural government subsidies, the nonstationary transfer ratio, and the joint insurance grant significantly and positively affect CE. The positive effect of prefectural government subsidies reflects the economic efficiency of an appropriate subsidy to insurers. The positive effect of the nonstationary ratio may imply that this is a necessary cost of maintaining a universal public health insurance system. The positive effect of the joint insurance grant indicates that this reinsurance scheme functions successfully as risk diversion to cover patients' expenditure following catastrophic medical events.

Table 4. Empirical Results of the Effects on Technical Efficiency

Method	Tobit	OLS	Tobit	OLS
Number of insured	-0.845***	-0.845***	-0.152***	-0.153***
	(0.256)	(0.256)	(0.022)	(0.022)
Squared number of the insured	-0.248***	-0.248***	-0.017**	-0.017**
	(0.074)	(0.073)	(0.007)	(0.007)
Fiscal adjustment subsidy	-0.174***	-0.174***	-0.017***	-0.017***
	(0.024)	(0.024)	(0.003)	(0.003)
Prefectural government subsidy	0.784***	0.785***	0.002	0.002
	(0.061)	(0.061)	(0.005)	(0.005)
Transfers from municipality	-0.162***	-0.158***	-0.007**	-0.007*
	(0.039)	(0.039)	(0.004)	(0.004)
Nonstatutory transfer	0.073***	0.073***	0.001	0.001
	(0.011)	(0.011)	(0.001)	(0.001)
Joint insurance grant	0.215***	0.215***	-0.004***	-0.004***
	(0.010)	(0.010)	(0.001)	(0.001)
Premium payment rate	-0.088***	-0.089***	-0.006***	-0.006***
	(0.020)	(0.020)	(0.002)	(0.002)
Contribution to the health care systems for the elderly	-0.353***	-0.353***	-0.008***	-0.008***
	(0.026)	(0.026)	(0.002)	(0.002)
Physician density	0.284***	0.286***	-0.021***	-0.021***
	(0.036)	(0.035)	(0.003)	(0.003)
Dentist density	-0.208***	-0.206***	-0.007***	-0.007***
	(0.020)	(0.020)	(0.001)	(0.001)
Hospital beds density	-0.057***	-0.058***	-0.002	-0.002

	(0.022)	(0.022)	(0.001)	(0.001)
Constant			0.847***	0.847***
			(0.003)	(0.003)
Standard error of the regression	0.336***		0.046***	
	(0.008)		(0.003)	
Number of observations	1705	1705	1705	1705
Log likelihood	-565.056	-552.180	2787.570	2825.921
R-squared	N.A.	0.850	-0.052	0.151

Note. ***, **, and * represent statistical significance at the 1, 5, and 10 percent levels. Robust standard errors are in parentheses.

Table 4 shows the results of the effects on TE. As with Table 3, the coefficients of the number of the insured, the fiscal adjustment subsidy, and the dentist density are significantly negative in all models, with and without a year effect. Moreover, the number insured squared, the transfer from municipal government, the premium rate and the contribution to the health care systems for the elderly also significantly and positively affect TE in both models. Although the effect of premium payment rate is contrary to expectation, its marginal effect is small. In the models without a year effect, the prefectural government subsidy and nonstationary transfer ratio also have significantly positive effects on TE as shown in Table 3.

Table 5. Empirical Results of the Effects on Allocative Efficiency

Method	Tobit	OLS	Tobit	OLS
Number of insured	-0.569***	-0.568***	-0.439***	-0.438***
	(0.120)	(0.120)	(0.109)	(0.109)
Squared number of the insured	-0.026	-0.026	0.018	0.018
	(0.033)	(0.033)	(0.026)	(0.026)
Fiscal adjustment subsidy	-0.050***	-0.050***	-0.021**	-0.021**
	(0.010)	(0.010)	(0.009)	(0.009)
Prefectural government subsidy	0.153***	0.154***	0.007	0.007
	(0.026)	(0.026)	(0.026)	(0.026)
Transfers from municipality	-0.039**	-0.039**	-0.011	-0.011
	(0.018)	(0.018)	(0.017)	(0.017)
Nonstatutory transfer	0.011***	0.011***	-0.002	-0.002
	(0.004)	(0.004)	(0.003)	(0.003)
Joint insurance grant	0.042***	0.041***	0.001	0.001
	(0.005)	(0.005)	(0.006)	(0.006)
Premium payment rate	-0.007	-0.008	0.008	0.008
	(0.009)	(0.009)	(0.009)	(0.009)
Contribution to the health care systems for the elderly	-0.062***	-0.062***	0.003	0.003
	(0.011)	(0.011)	(0.011)	(0.011)
Physician density	0.029*	0.029*	-0.028*	-0.029*
	(0.017)	(0.017)	(0.016)	(0.016)

Dentist density	-0.049***	-0.049***	-0.012	-0.011
	(0.008)	(0.008)	(0.008)	(0.008)
Hospital beds density	-0.007	-0.007	0.004	0.004
	(0.010)	(0.010)	(0.010)	(0.010)
Constant			0.158***	0.158***
			(0.011)	(0.011)
Standard error of the regression	0.190***		0.179***	
	(0.004)		(0.004)	
Number of observations	1705	1705	1705	1705
Log likelihood	409.755	416.004	505.808	512.297
R-squared	N.A.	0.446	-0.050	0.028

Note. ***, **, and * represent statistical significance at the 1, 5, and 10 percent levels. Robust standard errors are in parentheses.

Table 5 shows the results of the effects on AE. As with Tables 3 and 4, the coefficients of the number of the insured and the fiscal adjustment subsidy are significantly negative in the models both with and without a year effect. In addition, in the model without a year effect, transfer from municipal government, contributions to the health care systems for the elderly and dentist density significantly and negatively affect AE. In addition, the prefectural government subsidy, the nonstationary transfer ratio and the joint insurance grant significantly and positively affect TE in the model without a year effect.

5. Concluding Remarks

In this study, I use the JNHI municipal insurers' panel data to estimate their financial efficiency scores using nonparametric methods, and estimate the causal effects of structural and regional characteristics on the efficiency scores by econometric methods. I am attempting to obtain more robust and consistent results than those of previous studies. The estimated efficiency scores reveal that there are many insurers with serious financial inefficiencies and that CE is strongly and positively correlated with AE. The main empirical results of estimating the causal effects of various factors on the efficiency scores are as follows. First, the two major policy reforms to the elderly health care systems contribute greatly to improvement of the JNHI insurers' finances. Second, subsidies from prefectural governments positively affect efficiencies, but subsidies from central and municipal governments adversely affect them. Third, contributions to the health care systems for the elderly negatively affect JNHI finances, as Yuda (2016) has found.

The second finding indicates that some subsidies are not appropriate and have not fulfilled their original purposes. Specifically, the subsidy from prefectural governments improves insurers' financial efficiency, but those from municipal governments, and the uniform subsidy from the central government cause a soft budget problem. Because the size of the budget has been stable, it is necessary to reconsider allocation and structure to operate the public local health insurance system efficiently.

This reallocation would improve the efficiency of the JNHI system and social welfare. This result also implies that it is important that the prefectural governments that have supervisory responsibilities over their municipal insurers should more comprehensively manage them. This result bodes well for the reorganization of the JNHI system at the prefectural level, which is slated to occur in 2018. Moreover, I find that the contribution to the health care systems for the elderly negatively affects JNHI finances as suggested by the MHLW report (2016) and Yuda (2016). It is necessary to implement policy reforms to the elderly health care systems for the future maintenance of the universal public health insurance scheme and the JNHI system. According to recent Japanese studies, the price elasticity of the medical care of elderly patients is low (Shigeoka, 2014; Fukushima et al., 2016) and nonmonetary factors strongly affect their demand for outpatient health care (Yuda, 2007). These results would support an increase in the copayment rate and an actual restriction on the free-access system to control health care expenditure by the elderly appropriately.

Finally, if the government implements policy reforms to improve the finances of JNHI insurers, these will not necessarily improve the utility of representative individual enrollees or social welfare. A simulation analysis involving welfare economics is required to evaluate the effects on welfare of these policy reforms.

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References

Bates, L. J., Mukherjee, K., & Santerre, R. E. (2010). Medical insurance coverage and health production efficiency. *Journal of Risk and Insurance*, *77*(1), 211-229. http://dx.doi.org/10.1111/j.1539-6975.2009.01336.x

Chandra, A., Cutler, D., & Song, Z. (2012). Who ordered that? The economics of treatment choices in medical care. *Handbook of Health Economics*, *2*, 397-432. http://dx.doi.org/10.1016/B978-0-444-53592-4.00006-2

Charnes, A., Clark, C. T., Cooper, W. W., & Golany, B. (1985). A developmental study of data envelopment analysis in measuring the efficiency of maintenance units in the U.S. air forces. *Annals of Operations Research*, *2*(1), 95-112. http://dx.doi.org/10.1007/BF01874734

Coelli, T. J., Prasada Rao, D. S., O'Donnell, C. J., & Battesse, G. E. (2005). *An Introduction to Efficiency and Productivity Analysis*. New York: Springer.

Coelli, T. J. (1996). *A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program*. Centre for Efficiency and Productivity Analysis Working Papers, The University of New England.

Cummins, J. D., & Weiss, M. A. (2011). Analyzing firm performance in the insurance industry using frontier efficiency and productivity methods. *Social Science Research Network (SSRN)*. http://dx.doi.org/10.2139/ssrn.1997468

Dranove, D. (2012). Health care markets, regulations, and certifiers. *Handbook of Health Economics*, *2*, 639-690. http://dx.doi.org/10.1016/B978-0-444-53592-4.00010-4

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of Royal Statistical Society Series A (General)*, *120*(3), 253-290. http://dx.doi.org/10.2307/2343100

Fukushima, K., Mizuoka, S., Yamamoto, S., & Iizuka, T. (2016). Patient cost sharing and medical expenditures for the elderly. *Journal of Health Economics*, *45*, 115-130. http://dx.doi.org/10.1016/j.jhealeco.2015.10.005

Hashimoto, H., & Izumida, N. (2016). *Lectures on Health Economics*. Tokyo: The University of Tokyo Press (in Japanese).

Heckman, J. J., & Macurdy, T. E. (1981). A life cycle model of female labour supply. *Review of Economic Studies*, *47*(1), 47-74. http://dx.doi.org/10.2307/2297103

Honoré, B. E. (1992). Trimmed lad and least squares estimation of truncated and censored regression models with fixed effects. *Econometrica*, *60*(3), 533-565. http://dx.doi.org/10.2307/2951583

Ikeda, N., Saito, E., Kondo, N., Inoue, M., Ikeda, S., Satoh, T., ... Shibuya, K. (2011). What has made the population of Japan healthy? *Lancet*, *387*, 1094-1105. http://dx.doi.org/10.1016/S0140-6736(11)61055-6

Ikegami, N., Yoo, B.-K., Hashimoto, H., Matsumoto, M., Ogata, H., Babazono, A., ... Kobayashi, Y. (2011). Japanese universal health coverage: Evolution, achievement, and challenges. *Lancet*, *387*, 1106-1115. http://dx.doi.org/10.1016/S0140-6736(11)60828-3

Izumida, N. (2003). The scale of enrollee in the Japanese National Health Insurance system. In Y. Yamazaki, & Y. Ogata (Eds.), *Health System Reforms and Insurer's Functions* (pp. 121-136). Tokyo: Toyo Keizai Sinposha (in Japanese).

Kishida, K. (2002). Administrative cost of the Japanese National Health Insurance system and the economics of scale: Empirical evidence from panel data of municipal insurers in Kinki region's seven prefectures. *JCER Economic Journal*, *45*, 246-261 (in Japanese).

Le Grand, J. (2007). *The Other Invisible Hand: Delivering Public Services through Choice and Competition*. Princeton, Princeton University Press.

McGuire, T. G. (2000). Physician agency. *Handbook of Health Economics*, *1A*, 461-536. http://dx.doi.org/10.1016/S1574-0064(00)80168-7

Ministry of Health, Labour, and Welfare. (2016). Report on the financial conditions of municipal Japanese National Health Insurance System in 2014. Retrieved August 20, 2016, from http://www.mhlw.go.jp/file/04-Houdouhappyou-12401000-Hokenkyoku-Soumuka/0000112058.pdf

National Health Insurance Division, Health Insurance Bureau, and The Ministry of Health, Labour, and Welfare. (2006). The current situations and challenges of the Japanese National Health Insurance system. *Weekly Social Security*, *2394*, 34-39 (in Japanese).

Shigeoka, H. (2014). The effect of patient cost sharing on utilization, health, and risk protection. *American Economic Review*, *104*(7), 2152-2184. http://dx.doi.org/10.1257/aer.104.7.2152

Suzuki, W. (2001). An empirical analysis on consistency and incentive scheme in Japanese National Health Insurance subsidies. *Journal Personal Finance and Economics*, *16*, 91-103 (in Japanese).

Tajika, E., & Yui, Y. (1999). Population aging and national health insurance and long-term care insurance in Japan: From the perspective of public finance. *Quarterly of Social Security Research*, *35*(2), 128-140 (in Japanese).

Yamada, T. (1997). An examination of the administrative cost of the Japanese national health insurance and the economics of scale. *Research on National Health Insurance System and Local Government Finance* (pp. 17-31). Tokyo: National Institute for Research Advancement (in Japanese).

Yoshida, A., & Kawamura, A. (2008). *Budget systems and moral hazard in the national health insurance and the long-term care insurance*. Paper presented at the 2008 Japanese Economic Association Autumn Meeting, Higashi-Osaka, Osaka, Japan.

Yuda, M. (2007). An estimation of full price elasticity in the demand for outpatient medical services by the Japanese elderly. *JCER Economic Journal*, *57*, 23-52 (in Japanese).

Yuda, M. (2010). The minimum efficient scale of the insured in Japanese National Health Insurance. *Japanese Journal of Health Economics and Policy*, *21*, 305-325 (in Japanese with English abstract).

Yuda, M. (2016). Inefficiencies in the Japanese National Health Insurance system: A stochastic frontier approach. *Journal of Asian Economics*, *42*, 65-77. http://dx.doi.org/10.1016/j.asieco.2016.01.001

Zweifel, P., & Manning, W. G. (2000). Moral hazard and consumer incentives in health care. *Handbook of Health Economics*, *1A*, 409-459. http://dx.doi.org/10.1016/S1574-0064(00)80167-5

Notes

Note 1. The appendices to this paper are available at the author's website: https://sites.google.com/site/yudamichi/home/research

Note 2. CE is defined as the ratio of minimum cost to observed cost. See Equation 1.

Note 3. However, each effect cannot be estimated because they were introduced simultaneously on April 1, 2008.

Note 4. It should be noted that the life expectancy of the insured population might differ from that of the municipality as a whole because not all inhabitants of a municipality are insured through JNHI.

Note 5. Yuda (2016) additionally uses the proportion of retirees in the insurance pool as a proxy for aging, but it should be noted that the definition of this ratio differs between 2005 and 2010. The numerator in 2005 is the number of insured aged 65 years and over, but that of 2010 is the number of people aged 65 to 74 years, because of the introduction of the LHCS. Because this drastic change in the definition would affect the empirical results and make their interpretation more difficult, I do not use this variable in the regression. Appendix A presents the estimation results that include the retired enrollee ratio, and the results are fortunately similar to those in Tables 3-5.

Note 6. Appendix B presents the empirical results assuming CRS.

Note 7. Appendix C presents each insurer's estimated efficiency scores.

Note 8. The correlation coefficient between TE and AE is 0.015.