How successful was the policy of reformation of municipal hospitals in Japan?

– Estimation of the efficiency of Japanese hospitals using a dynamic and network data envelopment analysis model –

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Abstract: The purpose of this study was to perform an evaluation of the policy effect of the current reform of Japan's municipal hospitals. We focused on efficiency improvements both within hospitals and within two separate internal hospital organizations. Hospitals have two heterogeneous internal organizations: the medical examination division and administration division. We extend observation time from 3years to 6years to compare to previous version of this study. We also added new variable MRI as link variable.

Results showed that the average overall efficiency obtained with the DN-DEA model was 0.829 for 2007. The change in efficiency scores from 2007 to 2012 was slightly lower. The average estimated efficiency of both the administration division and medical-examination division decreased. We were unable to find any significant improvement in efficiency despite the reform policy. Thus, there are no positive policy effects despite the increased financial support from the central government.

Keyword: DN-DEA model, Japanese hospital, municipal, Malmquist index, MRI.

1. INTRODUCTION

Japanese municipal hospitals have experienced financial crises throughout the last few decades. In 2007, the Japanese government established a set of guidelines for municipal governments for reform and facilitated a restructure of hospital operations. There are 9,000 hospitals in Japan, half of which are owned by private not-for-profit organizations, and the remainder is run by public organizations. One thousand public hospitals are owned and operated by municipal governments, most of which have been losing money for long time.

As Japanese governments have huge cumulative deficits, it is important that municipal hospitals have sound financial foundations. The master plan for the reform of Japan's municipal hospitals includes five steps from fiscal year 2007 to fiscal year 2014 as described below. First, the central government designed guidelines regarding proposed reforms and a timeframe for those reforms in fiscal year 2007. The government ordered the reform of all municipals hospitals according to the guidelines. Therefore, all reformations of municipals hospitals were to start in fiscal year 2007.

The master plan for the reform of Japan's municipal hospitals includes five steps from fiscal year 2007 to fiscal year 2014 as described below. First, the central government designed guidelines regarding proposed reforms and a timeframe for those reforms in 2007. The government ordered the reform of all municipals hospitals according to the guide-lines. Therefore, all reforms were to start in fiscal year 2007.

Second, the central government ordered individual municipal hospitals to formulate a reform plan, including performance indicators for the evaluation of the reform within fiscal year 2008. The contents of the reform plan had some range of autonomy and municipal hospitals could freely select countermeasures.

Third, municipal hospitals are required to annually report the results of the reform plan to central government. The first report was submitted in fiscal year 2009.

Fourth, municipal hospitals were required to submit intermediate reports on the results of efficiency promotion from fiscal year 2007 to fiscal year 2010 at the end of fiscal year 2011.

Fifth, municipal hospitals are required to submit a final report on the results of the individual reform plan at the end of fiscal year 2014. The fiscal year 2014 is the deadline for the reform. If the reform has not been effective, then central government will request that the municipal hospital shut down or sell the operation of the hospital.

As explained above, the guidelines of the reform mainly target hospital administration because the main objective is to reduce deficit and to reduce the amount of subsidies received from local government. The central government is more interested in the financial situation of the hospital than the quality of medical services.

The guidelines illustrate several countermeasures for the reform of municipal hospitals. Such countermeasures can be grouped into four categories. The first is the introduction of private business management systems. For example, the guidelines recommend outsourcing to private companies and the adoption of a "Private Finance Initiative". The second category is the restructuring and consolidation of the hospital organization. For example, the guidelines recommend the merging of several hospitals and the conversion of hospitals into long-term care facilities. The third category refers to a reduction in hospitals' operating costs. For example, the guidelines propose a revision of wage systems and reductions in the purchase prices of medical materials. The fourth category is an increase in revenue. For example, the guidelines recommend increasing occupancy rates and unit values per inpatient (nearly equal to "unit revenue per inpatient per day").

Municipal hospitals can choose the countermeasures from the examples in the guidelines and can include their own reform countermeasures. Individual reform plans propose the recruitment of highly skilled professionals, further education for healthcare professionals and a revision of the range of medical services. Thus, each hospital formulates its own reform plan and then self-evaluates the results.

The purpose of this study is to evaluate policy effects of the reform for municipal hospitals in Japan. We estimated efficiency scores from 2007FY to 2012FY not only for the hospital as a whole but also for two divisions. In addition, we estimated Malmquist index score to evaluate dynamic change the efficiencies. We would like to consider further policy implications from the results.

2. METHOD AND DATA

The data used in this empirical investigation concerns 74 municipal hospitals from 2007FY to 2012FY in a balanced panel. There are approximately 1,000 municipal hospitals in Japan and there is large heterogeneity among them. We selected municipal hospitals with more than 300 beds. Therefore, this sample may represent larger acute hospitals owned by Japanese municipals. The data were collected from the Annual Databook of Local Public Enterprise published by the Ministry of Internal Affairs and Communications. It is a legal requirement that the local chief executive of municipal governments submit audited financial statements to the ministry. Therefore, the data should be accurate. Accuracy is required for DEA because it cannot take into account measurement errors in the data. DEA also implicitly assumes the correct model specification and the correct specification of inputs, outputs and other variables.

There are two heterogeneous internal organizations: a medical-examination division and an ad-ministration division. The administration division carries out business management activities to contain medical expenses within medical revenue. The medical-examination division provides various medical care services directly. These two organizations can be described as internal mutual exchange services. The administration division provides medical beds to the medical-examination division, and the medical-examination division repays the revenue through the use of medical beds for inpatient services.

The objective function of the administration division is to realize a sound financial situation through labor inputs and capital inputs. The objective function of the medical-examination division is to provide a certain amount of medical services using hospital beds that are maintained by the administration division at the same hospital. The DN-DEA model makes it possible to have a two-stage production structure in one hospital, that is, both the administration division and medical-examination division. The administration division raises funds for and maintains medical beds and expensive medical equipments. The medical-examination division uses the medical beds and medical equipments to provide medical services. Furthermore, the medical- examination division earns medical revenue in return for medical services and the administration division collects the revenue from the medical-examination division and manages financial matters. Previous literature that adopted traditional DEA models in the study of Japanese hospitals did not consider intermediate products in a hospital. In case of the DN DEA model, we can use link variables as intermediate products for both divisions. This benefit of the DN DEA model (compared with the traditional DEA model) is that it makes it possible to reflect on the actual situation. We adopted two link variables in our model.

In addition, if we add variables related to the administration division in the traditional DEA model, we would suffer from inadequate correspondence between inputs and outputs. For example, the administration staffs do not directly engage in the production of medical services. In the case of the traditional DEA model, this input may correspond with the number of inpatients as an output. However, the relationship between the administration staff and the number of inpatients would cause an undesirable bias in the efficiency estimation. Therefore, the DN-DEA model conceptually reduces bias in the estimation of efficiency by both considering the multiple-step production structure and by excluding inadequate interactions between inputs and outputs. However, we do not consider more detailed divisions in this study. For example, we did not consider pharmaceutical or clinical laboratory divisions.

Many previous studies that have adopted traditional DEA models to examine Japanese hospitals have focused on the activities of the medical-examination division. These studies typically adopt the number of doctors and nurses as inputs and the number of inpatients and outpatients as outputs. Therefore, such studies do not contain the activities of the administration division, by way of either input variable or output variable. However, the DN DEA model enables us to consider activities in both divisions. We can observe the activities of the administration division separately from the medical-examination division.

The inputs, outputs, links and carry-overs of the DN DEA model are described below. For Division 1 (administration division), we adopted two labor inputs and three capital inputs. The administration division does not directly provide a medical service to patients. The division is in charge of providing medical beds to the medical-examination division and maintains a sound financial situation for the hospital. Therefore, administration staffs should manage the financial situation of the hospital. They also receive subsidies from the municipal government and manage the reimbursement of issued hospital bonds. Maintenance staffs maintain all the hospital buildings for hospital activities. As labor inputs, we used both the number of administration officers and the number of maintenance officers. All labor inputs are full-time equivalents (FTEs). However, we did not consider staff differences in productivity and wage levels. As capital inputs, we used the interest cost for financial arrangements and municipal subsidies to cover deficits.

For the output of Division 1, we intended to adopt the “balance ratio of medical incomes to medical expenses”; the break-even point has a value of 1 and a surplus has a value exceeding 1. However, using a ratio as an input or output makes the convexity issue of DEA problematic [1]. Emrouznejad and Amin [2] recommended not using constant returns to scale when there is a ratio in the input/output variables. Therefore, we decomposed the ratio to medical income and medical expenses: the numerator was used as output for Division 1 and the denominator as input for Division 1.

For Division 2 (the medical-examination division), we adopted four labor inputs: the number of doctors, number of nurses, number of assistant nurses and number of medical technologists. All labor inputs were corresponding value of FTEs. For the outputs of Division 2, we adopted the number of inpatients per operation day, the number of outpatients per operation day and the number of beds in emergency units. In Japan, there is no gate-keeping system involving general practitioners. Therefore, hospitals accept a large number of outpatients to attract potential inpatients. In this study the number of beds in emergency units was used as a surrogate variable for emergency care service because we could not distinguish between emergency care patients and ordinary patients from the data source.

Previous studies regarding efficiency estimations on Japanese hospitals did not include emergency medical services. A core function of public hospitals in Japan is to ensure a quick response for emergency patients. However, some municipal hospitals have closed their emergency units to reduce costs despite the increasing need for emergency medical services. Although we consider that the evaluation of efficiency of municipal hospitals should include the number of emergency patients, we were not able to obtain numbers from the available data. Therefore, we adopted the number of emergency beds as a proxy for the number of emergency patients. This proxy variable has limitations because it did not control for the difference in severity of emergency patients, the quality of emergency medical service and the occupancy rate of the emergency beds.

The existence of a link variable is one of the key differences between the DN model and the BB model. The link variable is an intermediate product that acts simultaneously as an output for Division 1 and an input to Division 2. Using an intermediate product, we can evaluate multiple production steps among divisions in one DMU. Tone and Tsutsui [3] present four possible scenarios. For example, the “fixed link value case” means that the linking activities are unchanged.

There are peculiar characteristics in case of municipal hospitals comparing with private hospitals in Japan. Due to election tactics of governors, municipal hospitals tend to do overinvestment in both beds and expensive medical equipment. The decision of the investment was ordinary made by the administration division. We should count on the effect of capital investment from the administration division to medical-examination division.

We set the both “number of beds” and “number of tesra of Magnetic Resonance Imaging (MRI) scanners” as a link variable from Division 1 to Division 2. We assumed that Division 1 is in charge of the funding and maintenance of medical beds and expensive medical devices. Division 1 supplies these beds and devices to Division 2. Division 2 uses the medical beds and devices for delving medical care services to patients. We adopted a non-discretionary “fixed” link, where the linking activity remains the same. The reason for this is that it would be unusual for the medical-examination division to negotiate with the administration division to change the number of beds. The administration division also has an incentive to generate sufficient medical revenue (to offset the medical expenses) and to use all available beds. MRI scanners are expensive medical device and which are very popular in Japanese hospitals. The “tesra” means capacity of Magnetic power and means fineness of imaging diagnosis. We set the number of tesra of MRI scanners as proxy variable for expensive medical devices.

We used “average revenue per inpatient per day” as a link variable from Division 2 to Division 1. We assumed that the average revenue is the consideration to be paid to Division 1 for the beds from Division 2. The average revenue per inpatient may represent the density of medical care services. We adopted the “as-output” link, where the linking activity is treated as an output from Division 1. The reason for this is that this matter is not negotiable between the two divisions. Division 1 should be efficient enough to provide higher density medical services under the given resource constrains.

There are other peculiar characteristics in case of municipal hospitals comparing with private hospitals in Japan. According to the soft budget constraint, municipal hospitals can keep huge cumulative deficit. We need to consider negative effect of the deficit in our evaluation.

The carry-over variable is one of the benefits of using a DN model compared with a BB model. A DMU ordinarily continues activities over several terms. Furthermore, some inter-temporal factors can affect its efficiencies. The carry-over variable makes it possible to account for the effect from connecting activities between continuing terms. The carry-over variable has four characteristics in Tone and Tsutsui [3]. For example, “desirable (good) carry-over” variables are treated as outputs and a comparative shortage of carry-overs is seen as inefficiency.

We set the “balance account of the public enterprise bond (hospital bond)” as an undesirable (bad) carry-over. The hospital bond was chosen as the carry-over because municipal hospitals issue these bonds to raise funds for capital investment in terms of hospital beds. The municipal hospital gradually redeems the issued bond from any revenue surplus. We adopted the “undesirable (bad)” carry-over; thus, the connecting activity from Period 1 to Period 2 is treated as an input. The reason for this is that newly built hospitals are more attractive to patients but represent a heavier fiscal burden in terms of repaying the principal. Therefore, to treat the public enterprise bond as a carry-over reflects accurately the competitive condition of the market in which patients can freely access any hospital. However, we did not consider both the average life and interest rate of the hospital bonds.

According to the first principle that a public hospital is expected to accomplish a policy goal with a minimum budget, we selected an input-oriented model. We adopted both constant returns to scale (CRS) and variable returns to scale (VRS) models in the analysis. We also employed Malmquist productivity index (MI) number approach and decomposed MI to technological change (frontier-shift) and efficiency change of non-best-practice DMUs (catch-up). In case of Malmquist index, we selected CRS model according to the results from Tatje and Lovell [4]. Names of all variables in the analysis are provided in Table1.

Table 1: Names of all variables in the analysis

			Variable Names
Division1	Input	①	Number of administration officers
		②	Number of maintenance officers
		③	Interest cost per year
		④	Subsidy from municipal
		⑤	Medical expense
	Output	⑩	Medical income
Link(Div1→Div2)			Number of beds
Link(Div1→Div2)			Number of MRI
Division2	Input	⑥	Number of doctors
		⑦	Number of nurses
		⑧	Number of assistant nurses
		⑨	Number of medical technologist
	Output	⑪	Number of inpatients per an operation day
		⑫	Number of outpatients per an operation day
		⑬	Number of beds for emergency unites
Link(Div2→Div1)			Inpatient revenue
Carry over			Cumulative deficit

The number of inpatients per operation day decreased 3 percent point from 2007FY to 2012FY. The number of outpatients per operation day decreased 6 percent point from 2007FY to 2012FY. The balance ratio of medical expense to medical income improved 5 percent point (in the red) from 2007FY to 2012FY (Figure1).

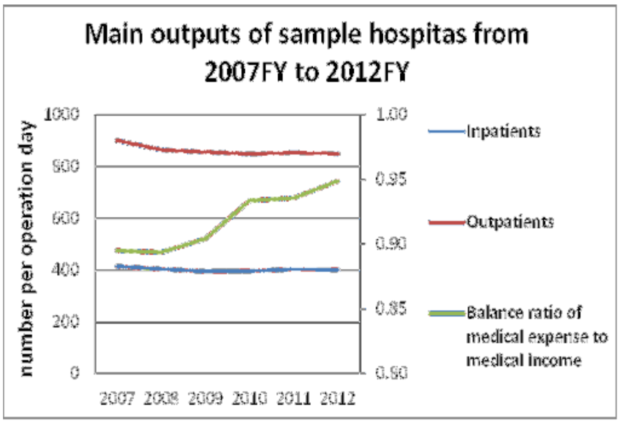

Figure 1: Main outputs of sample hospitals from 2007FY to 2012 FY

3. RESULTS

Table 3 presents the key statistics of the estimated efficiency scores obtained by the DN model. On the Table 3, the first row shows the efficiency scores of the overall hospital organization as determined by the DN model. The second row shows the efficiency scores of the administration divisions of the sample hospitals. The third row shows the efficiency scores of the medical-examination divisions of the sample hospitals. From the results of DN model, we obtained four key findings.

First, the average overall efficiency by the DN model was 0.91 (VRS model) for 2007FY. The average efficiency score estimated by the DN model was almost same level with the average efficiency level estimated in previous studies on Japanese municipal hospitals [5-8].

Second, the average level of relative efficiency on 2012FY is slightly less than on 2007FY in overall. The average efficiency score was 0.91 for 2007 and 0.89 for 2012FY (VRS model).

Third, because of the advantage of the network structure in the DN model, we can observe the efficiency change separately for different internal organizations. The average level of estimated period-divisional efficiency of the administration division decreased from 0.901 in 2007FY to 0.881 in 2012FY (VRS model). The average period-divisional efficiency of the medical-examination division also decreased from 0.921 in 2007FY to 0.909 in 2012FY (VRS model). On average, there was no significant efficiency improvement in both divisions for the 6-year period.

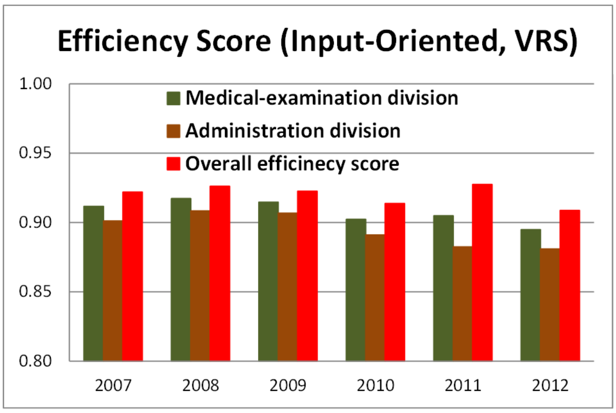

Figure 2: Estimated efficiency scores by DN-DEA

The Malmquist productivity index is suitable for evaluate dynamic change of efficiency of the samples. The average level of the Malmquist productivity index was 1.022 from 2007FY to 2012FY.

We can observe the efficiency change separately for different internal organizations. The average level of estimated Malmquist index of administration division increased from 1.58 from 2007FY to 2008FY, and 1.049 from 2011FY to 2012FY (CRS model). On the contrary, the average level of Malmquist index of the medical-examination division almost unchanged from 0.968 in 2007FY to 2008FY, and 1.002 from 2011FY to 2012FY (CRS model)(Table 2).

Table 2: Estimated Malmquist index scores by DN-DEA

division	model	Year	07→08	08→09	09→10	10→11	11→12
Division1 (admin)	CRS-I	Average	1.058	1.070	1.107	1.085	1.049
		SD	0.169	0.137	0.136	0.124	0.132
		Maximum	1.608	1.516	1.669	1.632	1.465
		Minimum	0.714	0.736	0.833	0.820	0.520
Division 2 (medical)	CRS-I	Average	0.968	0.980	1.001	0.972	1.002
		SD	0.074	0.106	0.113	0.090	0.118
		Maximum	1.275	1.494	1.385	1.478	1.554
		Minimum	0.761	0.641	0.693	0.750	0.786

The Malmqusit index of the administration division improved year by year about 6%.On the contrary, the Malmquist index of the medical-examination division seems to have no change during 2007FY-2012FY.To investigate the reason of the improvement of administration division, We decomposed the Malmquist index to frontier shift and catch up. The improvement of the Malmqusit index of administration division may come from "Frontier shift" rather than "Catch up" (Figure 3). As a conclusion, we cannot admit the policy effect in terms of efficiency improvement. However, there may be "technological change" in administration division as frontier-shift effect. We could not conclude that what is the technological change in administration division. However, we suspected that accounting standard had temporally loosened by financial support to hospital bond from central government to municipals.

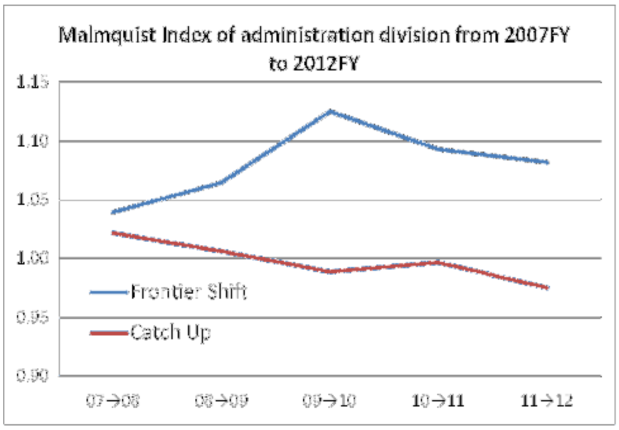

Figure 3 :Malmquist Index of administration division from 2007FY to 2012FY

4. DISCUSSION

Results from the efficiency estimation showed that the dynamic change in efficiency scores from 2007FY to 2012FY improved slightly but are not statistically significant. Thus, there are no positive policy effects despite the announcement. In addition, estimation results of malmquist index indicated an improvement of malmquist index in the administration division. The improvement of the Malmqusit index of administration division may come from "Frontier shift" rather than "Catch up" effect.

We suspect that the Frontier shift effect came from change of accounting standard for municipal hospitals and implicit subsidy from central government to the municipal hospitals. For example, central government permitted to issue "special hospital bond" with interest subsidy from central government and allowed to replace bad debts with cash from the special hospital bond. Total issuance of the special hospital bond reached 57,254 million yen (about 477 million dollars) on 2008FY.

This study would have several limitations that need to be addressed. For example, we were unable to use variables regarding the "quality" of medical services and the "severity" of patient condition. Therefore, we assumed that the sample hospitals would be homogeneous in terms of quality of service and severity of patient condition. We could, however, narrow the range of samples according to the number of hospital beds to ensure the homogeneity of the sample hospitals on some level. We used the number of beds in emergency units as an output and used total number of medical beds as the link variable. This double counting of medical beds could affect the results in some way.

There are other limitations regarding the control of several factors, which would influence to the estimated efficiencies. For example, the price of medical services, which is insured by public health insurance, changes every two years in Japan. The price increased on average by 2% in fiscal year 2008. However, sample hospitals have affected the change of reimburse rate of public health care insurance. Therefore, the relative efficiency scores would have small influence. Many Japanese acute hospitals decided to voluntarily change their reimbursement system from "fee for service" to "per diem based on diagnosis groups (DPC)". This study did not fully consider these external environmental changes in the Japanese hospital market.

Regarding policy implications, we did not consider both the relative costs of the two divisions and the relative costs to improve efficiency in each division. For example, one division may be less efficient on average, but the other may be more costly so that a given efficiency improvement is more beneficial. When playing an active role in policy implementation, we need to consider relative costs in addition to the efficiency scores. Future study will require a larger sample set and a more complex model.

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