Child Care Service Quality Management Through the Evaluation of Efficiency at Child Care Centers : An Evaluation with Data Envelopment Analysis

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Abstract

This paper proposes a scheme to estimate the technical efficiency at child care centers for the less-than-three-year-old infants by Data Envelopment Analysis (DEA) and to manage the quality of care service through implementing flexible and efficient government subsidy system. The result of technical efficiency estimation shows that there exists the heterogeneity in technical efficiency a substantial opportunity for improvement in technical efficiency across child care centers. This result implies that government may bring up the competition by giving subsidy differentially based on efficiency and use the money which has been used inefficiently other purposes. Both can improve the quality of child care service.

1. Introduction

Over past 20 years, child care service has focused on the expansion of beneficiary children rather than the efficiency in the operation of child care centers or the quality of child care service. Huge budget and efforts have been committed to increase the number of children who are served by child care facilities. Since the legislation of the Child Care ACT in 1992, child care policy has focused more on the expansion and the last government raised the scale of subsidy considerably. This trial for the expansion in quantity is now to cope with the soaring demand for child care service generated by woman's more engagement in social work (Kang *et al.*, 2006). For this expansion in the number of service capacity, government has given a subsidy both to child care centers and to low-income parents who want to send their children to a child care center. Child care centers are given the subsidy of 30% of labor cost for the classes for the over-2-year-old infants and 80% of labor cost for the classes for the-less-than-2-years-old infants and parents are given a pre-determined percent of tuition based on their income level.

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Although the fact that the ratio of the number of children cared by child care centers to that who want to be cared is below 30% implies that the expansion policy is still essential (Lee, 2002; http://blog.naver.com/fightting?Redirect = Log&logNo = 150003059249), because of the characteristic that child care service must play both roles of education and nurturing simultaneously it is necessary to think about the efficiency and quality of child care service. In fact, this large size of subsidy plan may bring out some inefficiency in the use of it and traditional Pigouvian subsidy like current subsidy system never leads centers to be efficient and to improve their quality of care service (Kim and Kim, 2005). These result in the waste of tax and the decline in child care service quality.

In this context, this paper tries to evaluate the efficiency at individual child care center and to grope the direction of improvement in the quality of child care service utilizing the evaluated efficiency score. To consider the efficiency of child care centers, it is necessary to classify them into two groups: centers for the less-than-3-year-old infants and centers for the over-two-year-old infants because the cost structure of two groups is quite different. While over 70% of care cost of centers for the less-than-3-year-old infants is for labor cost for teachers, center head, and cooks *et al.*, labor cost takes only about 40%~50% in centers for the over-two-year-old infants. Therefore, the efficiency at two groups should be evaluated with different factors. This paper covers the efficiency at centers for the less-than-3-year-old infants.

In the case of child care centers which this paper is interested in, since one teacher should be in charge of 3 infants, 5 infants, and 7 infants for 0 year old, 1 year old, and 2 years old class, respectively, at least 70% of total care cost is labor cost and other costs are almost ignorable (Lee and Park, 2006). In this situation, it is possible to evaluate the efficiency at them by focusing on the efficiency of teachers. In addition, since 80% of labor cost for the child care centers is supported by government (Just 30% for the centers for older infants) (MOGE, 2007), it is more likely for them to be inefficient in the use of teachers.

The inefficiency in the use of teachers will come from the over-employment of teachers and wrong assignment of them to wrong class, which implies that subsidy from government may be substantially wasted. As noted, the accurate evaluation of efficiency of teachers allows for the quality management of child care service through subsidy based on the heterogeneity in efficiency and efficient implementation of subsidy system. The reasons why technical efficiency is selected for performance measure are that it is evaluated relatively to child care centers with best performance rather than to those with average performance and that it can take multiple inputs and outputs into account simultaneously (Charnes *et al.*, 1993).

Farrell (1957) initially insisted that evaluation of technical efficiency is meaningful for decision making units (DMUs) in that it may measure how much a DMU can decrease input factors keeping current level of outputs. Equivalently, technically inefficient DMUs can be brought towards efficiency by cutting down overused inputs. Child care centers (DMUs) can

also improve their overuse of inputs and government can monitor how efficiently the subsidy is implemented reasonably through the evaluation of technical efficiency. As the approach to evaluate the technical efficiency, this paper employs Data Envelopment Analysis (DEA) because it does not require the assumption of the functional specification between input factors and output factors and also includes multiple outputs unlike stochastic frontier model.

One application of DEA to child care in Korea is found (Ryoo and Kim, 2006). They tried to measure technical efficiency at each city with child care budget and number of civil servants who engage in child care service as input factor and capacity of child care service, number of children served currently, and number of child care centers as output factor. This paper will be the first paper which tries to evaluate technical efficiency at individual child care center. Moreover, this paper compares technical efficiency of child care centers according to their type such as private, public, small private, corporate, and others

Next section discusses the theoretical approach of DEA briefly. Section 3 covers data collection and the summary of data. Section 4 illustrates the result from empirical evaluation of technical efficiency. Conclusion follows in section 5.

2. Theoretical Backgrounds

The necessity of problem for the evaluation of technical efficiency was recognized by Farrell (1957) and Charnes *et al.* (1978). The measure of Farrell efficiency can be defined following the research for a set of N DMUs ($n = 1, \cdots, N$), each with access to the same technology that transforms a vector of variable inputs into a vector of outputs. More generally, for the DMUs, it is possible to define a $(I \times N)$ input space, X, and a $(J \times N)$ output space, Y. Suppose the technology satisfies the regularity conditions adopted by Banker et al. (1984). The production possibilities set for firm n_0 can be expressed by the following linear technology:

$$P = \left\{ (y_{n_0}, x_{n_0}) | x_{n_0} \geq z_n x_n, y_{n_0} \leq z_n y_n, I' z_n \in R_+^N \right\} \tag{1}$$

where $z_n = (z_{n,1}, \cdots, z_{n,N})$ is the set of intensity variables with elements indicate the intensity with which each DMU's production scheme is taken into account in the construction of the technology frontier (Cooper *et al.*, 2000). By equation (1), DMU n_0's production scheme (x_n, y_n) belongs to the production possibilities set, if and only if, $(x_n, y_n) \in P$. Input-based technical efficiency is defined for the DMU n_0 as follows.

$$\underset{\lambda_{n0}, z_n}{Min}\ \lambda_{n_0}$$

$$z_n x_{n,i} \leq x_{n_0,i}\lambda_{n_0},\ i = 1,\ 2,\ \cdots,\ I \qquad (2)$$
$$y_{n_0,j} \leq \sum_{n=1}^{N} z_n y_{n,j},\ j = 1,\ 2,\ \cdots,\ J$$
$$I' z_n = 1$$

Equation (2) illustrates the BCC-DEA models developed by Banker *et al.* (1984), assuming the variable returns to scale (VRS).

Range of technical efficiency among child care centers is employed as the measure of heterogeneity in efficiency and the measure of opportunity for improvement in efficient is the difference of technical efficiency score from one. Finally, ANOVA is employed to compare the efficiency among types of child care centers.

3. Data and Empirical Issues

The data on operation of child care centers for less-than-three-years-old-infants in 2006 for efficiency evaluation were collected from the web page of Korean Ministry of woman and family. The size of sample is 251 and they are classified into 5 types of private, public, small private, corporate, and others according to who found them.

The model for efficiency evaluation is specified with two output categories (current enrollment of less-than-two-years-old infants and current enrollment of two-years-old infants) and three variable input factors (number of teachers, care capacity for less-than-two-years-old infants, and care capacity for two-years-old infants). Current enrollments are undisputable output measure of child care centers because the more children may imply the better child care service. Number of teachers becomes the most important input factor because over 70% of total standard child care cost for less-than-three-year-old infants consists of labor cost for teachers and care capacity also becomes an input factor in that it reflects the state of other inputs such as facility investment, learning material, and operation costs etc. which take about 20~30% of standard child care cost (Lee and Park, 2006).

In order to guarantee the robustness of DEA results, it is very important to determine the model specification appropriately because DEA is dependent on extreme points. As a measure for evaluation of appropriateness of model specification, dimensionality $(= \frac{\#\ of\ trucks}{\#\ of\ input\ factors\ +\ \#\ of\ output\ factors})$ can be used (Fernandez-Cornejo, 1994). If it is greater than 5, the model specification looks good. Since the dimensionality of this research is greater than 50 $(\frac{251}{3+2} \cong 50)$, this model specification is acceptable. Table 1 illustrates the summary of data for all samples and Table 2 illustrates the summary of data for each type

of samples. It is possible to check that child care centers included in sample have the substantial variations in both input factors and output factors and between types of centers from Table 1 and Table 2. These variations look appropriate to evaluate technical efficiency of each center with respect to other centers (Fernandez-Cornejo, 1994).

Table 1. Summary of data for whole sample

Variables	N	Min	Max	Mean	Standard Deviation
Care capacity for the less-than-2-year-old	251	5	48	18	7.19
Care capacity for the 2-year-old	251	0	70	24	9.62
Number of teachers	251	2	15	6	2.37
Current enrollment of the less-than-2-year old	251	2	42	16	6.80
Current enrollment of the 2-year old	251	1	55	21	9.54

Table 2. Summary of data for each group

Variables	Private centers		Public centers		Small private centers	
	N	Mean	N	Mean	N	Mean
Care capacity for the less-than-2-year-old	64	17.06	31	21.06	5	11.40
Care capacity for the 2-year-old	64	21.56	31	27.00	5	8.60
Number of teachers	64	5.59	31	7.74	5	3.00
Current enrollment of the less-than-2-year old	64	15.94	31	19.58	5	11.80
Current enrollment of the 2-year old	64	17.45	31	22.39	5	8.20

Table 2 (cont'd). Summary of data for each group

Variables	Corporate centers		Others	
	N	Mean	N	Mean
Care capacity for the less-than-2-year-old	45	24.16	106	15.73
Care capacity for the 2-year-old	45	32.80	106	22.18
Number of teachers	45	8.04	106	5.43
Current enrollment of the less-than-2-year old	45	17.80	106	13.79
Current enrollment of the 2-year old	45	27.80	106	19.51

4. Results and Discussion

Technical efficiency for 251 child care centers for the less-than-3-year-old infants, where their labor cost is subsidized by government. The interpretation of technical efficiency is that keeping current enrollment of each age-class, the corresponding child care center can reduce the number of teachers and care capacity by the ratio of (1-technial efficiency score). For example, suppose that the technical efficiency score of a center is 0.75. The center must reduce its number of teachers and care capacities by 25% in order for it to be efficient keeping current enrollment.

The summary of technical efficiency evaluation in Table 3 also shows the existence of heterogeneity in efficiency at child care centers, substantial opportunity for improvement, and, as the result, the possibility for saving of government subsidy to labor cost. The existence of heterogeneity can be verified by the results that the ranges of technical efficiency are 79.50% (1-0.2050) for all samples, 65.71% (1-0.3429) for private centers, 72.69% for public centers, 36.79% for small private centers, 60.19% for corporate centers, and 79.50% for other centers. This implies that child care centers even belonging to the same type are different in the use of teachers and, for this reason, subsidy from government should be given differently according to their technical efficiency in order for them to become more efficient. Although the existence of this heterogeneity in efficiency is verified, if government subsidy is given to child care centers uniformly like Pigouvian subsidy inefficiency holds out continuously and the opportunity to improve the quality of child care service through sweeping away inefficiency will disappear. Therefore, government subsidy should be given considering this heterogeneity.

For improvement opportunity, child care centers belonging to each type will be able to improve their efficiency by 25.98%, 20.70%, 20.86%, 24.05%and 25.03% on the average and all child care centers will be able to improve by 24.49%. From this result, it is possible to think about the possibility of saving of government subsidy. The fact that inefficiency of child care centers for the less-than-3-year-old infants in the use of teachers subsidized by government is 24.49% means that the same ratio of labor cost is over-paid. Since government subsidized 80% of labor cost for child care centers for the less-than-3-year-old infants, it is possible to say that about 19.6% of government subsidy is wasted by the inefficient use of teachers. Expressed by money, approximately ₩43,060 million may be wasted only in subsidy to labor cost in 2007. Sum of standard labor costs/child and month (Lee and Park, 2006) for the less-than-3-year-old infants is about ₩1,283,252 in child care center with 100 care capacity and that for the over-3-year-old infants is about ₩430,174. Of these values, since 80% for the first is subsided while 30% for the latter is subsided, subsidies are ₩1,026,602 and ₩129,052, respectively. The ratio of the two values is 8 : 1 and ₩247,158 million which is total subsidy to labor cost (MOGEF, 2006) is distributed by the ratio

(₩219,696 million: ₩27,462 million). The 19.6% of ₩219,696 million is ₩43,060 million. Therefore, the improvement in the inefficiency in the use of teachers results in the saving of a big money and this saving will be utilized as a budget to improve the quality of child care such as the expansion of facility and learning materials. Taking account of the fact that the subsidy budget for learning material and care facility is just ₩22,265 million in 2007 (MOEG, 2006), the additional investment of ₩43,060 million to them will contribute to the improvement in care quality outstandingly. Though the level of waste for each type of child care centers is slightly different, the difference does not look statistically significant.

Table 3. Summary of results from technical efficiency evaluation of all child care centers

	All	Private	Public	Small private	Corporate	Others
Average efficiency (%)	75.51%	74.02%	79.30%	79.14%	75.95%	74.97%
# of efficient centers	70	15	12	0	13	30
% of efficient centers	27.89%	23.44%	38.71%	0.00%	28.89%	28.30%
Minimum efficiency (%)	20.50%	34.29%	27.31%	63.21%	39.81%	20.50%

In order to verify whether there are some differences in technical efficiency among types of child care centers, ANOVA test was employed. Table 4 shows the result from it. As noted in Table 4, because F-value of ANOVA is very small and p-value is far greater than significant level (i.e. 0.05), the null hypothesis that technical efficiency scores for different types of child care centers are statistically equal is accepted. Therefore, it is possible to conclude that difference in type does not make any difference in the technical efficiency at child care centers. This implies that it is not necessary for government to subsidize child care centers based on their types differently.

Table 4. ANOVA result for the difference in efficiency among types of child care centers

	Sum of Squares	d.f.	Mean Square	F-value	p-value
Between Groups	.072	4	.018	.397	.811
Within Groups	11.051	245	.045		
Total	11.123	249			

5. Conclusion

This paper deals with topic on the evaluation of the performance of child care centers for the less-than-3-year-old infants in order to examine the approach to appropriate quality man-

agement of child care service. Now, although Accreditation of Child Care Centers is being enforced to manage the quality of child care services (Lee, 2002) it does not look sufficient because it is based on a grading system and it is proven not to be so successful (Song, 2006). Thus, this paper starts from the idea that there can be more successful system in the management of quality of child care service than Accreditation of Child Care Centers. Technical efficiency based on production function of child care centers was chosen as the performance measure and DEA was employed in order to estimate technical efficiency. As the result, it was possible to confirm some meaningful findings and get some important intuition.

Child care centers for the less-than-3-year-old infants show the existence of substantial size of inefficiency and the substantial heterogeneity in technical efficiency. That is, while some centers are efficient, others are inefficient considerably although they are included in a type and have similar capacity and size. This says that over-employment or unreasonable assignment of teachers exists within child care centers and investment to learning material and facility is not so efficient.

Implication of the existence of heterogeneity in efficiency among child care centers is that government subsidy should not be given uniformly like under current system but should also be given to centers differently according to their efficiency. This differentiated subsidy leads child care centers to the effort for the improvement in efficiency and this effort will result in the improvement in care quality by appropriate operation of them which is needed to become efficient.

The existence of inefficiency and the possibility of improvement in technical efficiency suggest the opportunity of a huge saving of government subsidy. This inefficiency reflects the waste of a part of subsidy and as the result, the improvement in the inefficiency results in the saving of the waste. If this saving could be reinvested to improve the quality of child care service, it is possible to improve it outstandingly. Moreover, since the type of child care centers does not affect technical efficiency of them, it is not necessary to consider the differentiated subsidy among child care centers included in different types of them.

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