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By

Taiyo Fukai (The University of Tokyo)

April 2021

CREPE DISCUSSION PAPER NO. 98

CENTER FOR RESEARCH AND EDUCATION FOR POLICY EVALUATION (CREPE)
THE UNIVERSITY OF TOKYO
http://www.crepe.e.u-tokyo.ac.jp/

How elastic is capacity choice in welfare facilities? Evidence from notches in Japan's childcare subsidy scheme[*]

Taiyo Fukai[†]

April 14, 2021

Abstract

Many countries are struggling to provide childcare services to help people balance work and family life, but the focus has tended to be on building new facilities rather than making more effective use of existing facilities. In this study, we estimated the critical structural parameters for the supply of childcare services and conducted policy simulations by scrutinizing the institutional design of public childcare services in Japan. Specifically, we focused on the amount of money each facility receives per child admitted, or the *unit cost of childcare*, which is funded by a combination of government subsidies and user fees. As this amount decreases discontinuously with the size of the facility, this creates an incentive for facilities to not increase their size any further, which causes facilities to bunch at a threshold. This degree of bunching has information that allows us to identify structural parameters that specify how elastic the supply of capacity is to the unit cost. Policy simulations using this model show that it is possible to expand the supply of childcare centers without increasing the burden on either government or users by eliminating these discontinuities. This result provides a new perspective on the usefulness of identifying key production parameters and optimizing the existing infrastructure, rather than only considering the construction of new facilities.

Keywords: Childcare, Aging society, Bunching, Social welfare facilities
JEL codes: H32, H53, J13, J18, L30.

[*]I would like to express my deepest appreciation to Daiji Kawaguchi and Hidehiko Ichimura. I am also grateful to David Card, Christian Dustmann, Chishio Furukawa, Takuya Hasebe, Hiroyuki Kasahara, Keisuke Kawata, Hiroshi Ohashi, Yoshiaki Omori, Takahiro Toriyabe, Masayuki Yagasaki, Atsushi Yamagishi, Yuichiro Yoshida and conference participants at the CREPE Conference on Program Evaluation, Tokyo Labor Economics Workshop, Yokohama National University, Yokohama City University, Hiroshima University for their valuable comments. This research is supported by JSPS KAKENHI Grants 16J08836 and 18J21486. The use of data in this paper has been approved by the Ministry of Health, Labour and Welfare. Editing assistance was provided by Philip C. MacLellan. All responsibility for errors remains with the author.

[†]Researcher, Economic and Social Research Institute, Cabinet Office, Government of Japan; Project Researcher, Department of Economics, the University of Tokyo (fukai@e.u-tokyo.ac.jp).

1 Introduction

As the fertility rate continues to decline in Japan while the gender gap in employment continues to narrow, the increased prevalence of two-income families and declining population means that the demand for policies that support a healthy work-life balance for families is of critical importance. In particular, public childcare facilities are playing an increasingly important role in supporting women who are raising children while working. Previous studies have shown that an increased availability of childcare facilities has the effect of increasing the employment rate of mothers (Baker et al., 2008; Fitzpatrick, 2010; Havnes and Mogstad, 2011; Nollenberger and Rodríguez-Planas, 2015; Bauernschuster and Schlotter, 2015; Nishitateno and Shikata, 2017; Yamaguchi et al., 2018a), increasing the birth rate (Rindfuss et al., 2010; Bauernschuster et al., 2016; Fukai, 2017), and supporting child development (Havnes and Mogstad, 2015; Cornelissen et al., 2018; Yamaguchi et al., 2018b). Moreover, adequate access to childcare centers has been shown to be a financially beneficial policy not only in the short-term but also in the long-term because it brings social benefits through the accumulation of human capital not only for parents today but also for their children in the future (Heckman, 2006; van Huizen et al., 2019).

Although the provision of public childcare services is a worthy goal, Japan and developed countries in Europe are facing the problem of not being able to easily expand the provision of services. For example, the European Council declared that by 2010 at least 90 percent of member countries should have access to childcare centers for children over the age of three, and 33 percent for children under the age of three (European, 2002). However, in 2013, the European Commission concluded that these goals had not been achieved (Melhuish, 2015). Figure 1 shows the utilization rate of childcare centers in OECD countries, and it is clear that while most children are able to attend a childcare center at the age of five in many countries, the utilization rate for children under three is less than 40 percent.

Previous studies have discussed the role of regulatory burdens in preventing the expansion of childcare centers (Bauernschuster et al., 2016; Yamaguchi et al., 2018a). In many countries, various operational standards must be met in order to establish a new childcare facility. For example, standards regarding the minimum land area that needs to be allocated per child make it difficult to find land to build new facilities. Furthermore, there is a need to maintain a stable supply of professionally qualified childcare workers. Against this backdrop, increasing the number of childcare centers is not a trivial matter and, as a result, long waiting lines are observed in many countries.

One perspective that seems to be missing in this line of research is a discussion of whether existing facilities can be used more efficiently. For example, a breakdown of the financial resources used in public childcare services in OECD countries (Figure 2) shows that a large amount of public funds are invested in these services. How are these public subsidies decided upon and how are they used by each facility? To the best of my knowledge, there is no discussion that focuses on the structure of the market for such existing facilities.

In particular, the role of supply-side incentives are beginning to be recognized as an important factor in the provision of public services. For example, it has been found that when reforms are implemented that impose new regulations to ensure the quality of childcare services, there is an exodus from the market in areas where the demand side has a low willingness to pay for quality (Hotz and Xiao, 2011). On the other hand, it has also been reported that subsidizing hospitals on the supply side has allowed more economically disadvantaged households to be accepted by hospitals (Gruber et al., 2014). Furthermore, Einav et al. (2018) highlight the importance of supply-side incentives to ensure proper hospital care, for insurance payments become constant after a certain period of hospitalization, which can cause the hospital to prematurely discharge the patient. However, simply increasing subsidies does not seem to be the answer, as Kondo (2019) finds that increases in government subsidies to facilities has tended to not be passed on to employees. Therefore, it is necessary to explore alternative structural mechanisms on the supply side to ensure that this financial support can translate into improved services. Thus, a stream of research has begun to learn how supply incentives can be used as a tool to improve the supply of services, and to use structural parameters to seek a better institutional design.

This study follows this line of research. In order to scrutinize the institutional design of public childcare services in Japan, we first utilize a unique policy variation to estimate the critical structural parameters for the supply of childcare services, and then we use this information to conduct policy simulations. Specifically, we focus on the *unit cost of childcare*, which is the amount of money each facility receives per child admitted, and is funded by a relatively equal balance of government subsidies and user fees. We estimated the structural parameters related to the production technology exploiting that this variable decreases discontinuously with the size of the facility.

Importantly, at the point of discontinuity, there is an incentive to not increase the size of the facility any further, which leads to a concentration of facilities at that threshold. This degree of bunching has information that allows us to identify structural parameters that specify how elastic the supply of capacity is with respect to the money received by each facility per child. We confirm that these theoretical predictions are consistent with the observed distribution of childcare capacity in practice. Furthermore, the model was estimated via a simulated method of moment using real-world data, and the elasticity of the childcare supply to the unit cost of childcare was found to be about 0.2. From this policy simulation, it was found that the supply of childcare centers can be further expanded while reducing the governmental/parental burdens either by eliminating the discontinuity in the unit cost of childcare or by using other unit cost settings. This result provides a new perspective on the usefulness of identifying key production parameters and reconsidering the existing system, rather than only looking at building new facilities.

The main contributions of this study are as follows. First, to the best of our knowledge, this is the first paper to estimate the elasticity of supply of subsidies in public social welfare services using a clear identification strategy. While previous studies have attempted to directly estimate quality-adjusted cost functions for childcare facilities from observed data, they have not been able to identify unobserved heterogeneity with respect to structural parameters (Mocan, 1997; Blau and Mocan, 2002). In our analysis, the progress is that we are able to clearly identify structural parameters by exploiting exogenous institutional design, with our analysis inspired by the bunching method Kleven (2016) that has been developed in recent years to identify structural parameters based on distortions in the behavior of economic agents due to institutional design.

In addition, our results provide a new perspective for solving the serious problem of children waiting for social welfare services, and we believe that they have significant policy implications. The findings of this paper will help to inform not only the provision of childcare, but also other public social welfare policies such as public long-term care, which is heavily regulated and funded by public money and yet still suffers from insufficient supply (Hussein and Manthorpe, 2005; Nishimura and Oikawa, 2020).

The rest of the paper is organized as follows: Section 2 explains the institutional background of Japan's public childcare system and the unit cost of childcare. Sections 3 and 4 describe the theoretical predictions of a discontinuous subsidy scheme and graphical evidence using real-world data. Section 5 presents the empirical method, our main results and policy experiments, and Section 6 concludes the paper.

2 Institutional background

In this section, we first provide a general overview of Japan's public childcare system, focusing on the supply side of the system. Then we explain the details of subsidies in the public childcare system, the subject of our analysis. By knowing the details of the subsidy system, we hope that the reader will understand the source of identification for our analysis.

2.1 Overview of Japan's public childcare system

This paper focuses on accredited childcare centers, which provide facility-based public childcare services in Japan. Accredited childcare centers, commonly known as daycare centers, provide full-day care for children from 0 years old to preschool age, and are the primary childcare service that accounts for more than 90 percent of the use of facility-based childcare services in Japan (Asai et al., 2015). The local government approves accredited childcare centers if they meet certain standards and also oversees their management. In some cases, the actual operation is run by the municipality, while in other cases, it is run by a private organization such as an NPO. Hereafter, when we refer to childcare centers in this paper, we are referring to these accredited facilities.

To provide childcare services as an accredited childcare center, the provider must meet several criteria. For example, a private organization operating a facility must use accepted accounting methods. Also, regarding the childcare center's actual operations, there are minimum standards regarding capital such as a minimum facility size per child and space for an office and a kitchen. There are also several labor-related standards, including requirements that childcare workers must be qualified by the government and that a minimum number of childcare workers must be assigned to each child per age group.

Once a childcare facility meets the standards and is approved to operate, it will be funded by subsidies from the national and local governments in addition to user fees. One of the main features regarding the operating costs of accredited childcare centers is that the expected operating costs are set in advance by the government, and subsidies are paid accordingly. The central government subsidizes 37.5 percent of the total estimated cost, while prefectures and municipalities together subsidize 12.5 percent of the total cost, meaning that 50 percent of the total cost is subsidized by public funds and the remaining 50 percent is to be collected from the users of the childcare facilities[1].

2.2 The unit cost of childcare

The estimated cost of operating an accredited childcare center, as described above, is determined by accumulating the various costs involved in caring for each child. The public childcare system in Japan uses an age-based system to determine labor needs, stipulating the number of childcare workers required to care for one child of each age. Therefore, the labor cost of caring for a child of each age can be determined once the childcare workers' wages are known. This information is available because childcare workers' wages are not based on market wages, but rather on the salary schedule of national government long-term care workers, which is set in advance. In addition to labor costs, utility costs and administrative costs necessary for the facility's operation are added up to calculate the cost per child, which is called *the unit cost of childcare*.

In actual operations, operating budgets are determined in the following manner. First, each facility decides on the number of children it will accept in the next fiscal year. The determined capacity is then reported to the local government, which then admits the children who have applied based on that capacity. Once a child is admitted to the facility, the operating costs are determined by multiplying the unit cost of childcare by the number of children admitted. Once the operating budget is determined, each facility will need to make ends meet within the operating budget. Each facility is allowed to accept no more than the capacity of children, but not more than children's capacity. Therefore, it is not easy to manipulate the operating budget after the capacity has been decided.

The unit cost of childcare is an essential factor in determining the budget available to each

[1] In reality, each municipality provides further subsidies, so the users' share of the cost is often less than 50 percent

childcare facility, and it has the following important characteristics. First, there are differences depending on the age of the child. Under the system, the child/staff ratio, or the number of children that can be cared for by one childcare worker, is smaller the younger the child is. Therefore, the unit cost of childcare differs depending on the age of the children in the facility, and the lower the age of the children, the higher the unit cost of childcare. Next, and crucial for this paper, the system assumes economies of scale by convention, with the unit cost of childcare decreasing as the facility size increases.

In this way, the operating cost subsidy that each childcare facility receives differs depending on the size of the facility, with the shape of the profile being particularly noteworthy. Figure 3 shows the profile of the monthly unit cost of childcare per child and the facility capacity at facilities that care for children, using a typical age structure. The horizontal axis shows the capacity rather than the number of children actually accepted at each facility[2]. As shown in Figure 3, the unit cost of childcare decreases as the capacity, which is the facility's size, increases. What is noteworthy is that the profile of the unit cost of childcare is a staircase pattern depending on the capacity category. For example, in a childcare facility with a capacity of 60 children, the monthly unit cost of childcare is calculated at just over 60,000 yen, but as the capacity increases to 61 children, the monthly unit cost decreases discontinuously to just over 50,000 yen. In this way, the unit cost of childcare is determined for each capacity category, so a facility that reports a capacity of 61 children receives that lower subsidy even if the actual number of children it accepts is 60 or less.

Figure 4 illustrates the actual operating budget that the facility would receive for each capacity level, based on the profile of childcare unit costs in Figure 3. The operating budget here is the sum of government subsidies and user fees. Due to the step-wise profile of the unit cost of childcare, the operating budget of each facility also falls discontinuously after each capacity threshold. Where the difference is large (at 60 or 90 children, for example), the monthly operating costs received can vary by more than 500,000 yen for a single additional child in capacity.

This structure of discontinuous decreases in the subsidies received should create strong incentives not to increase the capacity near the thresholds. The idea of this paper is to estimate the fundamental parameters in the provision of childcare facilities based on information regarding how much such incentives drive the capacity decision of the facility. In the next section, we will

[2]The capacity is not set for each age group, but refers to the total number of children that the facility can accept.

examine in detail how each entity changes its decision-making, as well as the economic model.

3 Model

The literature on non-linear constraints and their effects on the decision-making of economic agents is robust (Hausman, 1985; Blundell and Macurdy, 1999), and has examined a variety of areas such as changes in labor supply in response to nonlinearities in tax rates (Saez, 2010; Chetty et al., 2011; Kleven and Waseem, 2013), nonlinear automobile fuel economy regulations and automobile production (Ito and Sallee, 2018), and hospital patient admissions using non-linear insurance schemes (Einav et al., 2018)[3]. In these studies, the use of simple models has helped to clarify the implications of these constraints. In this study, we follow the literature by first organizing the theoretical implications of the staircase-shaped unit cost of childcare shown in Figure 3 by considering the decision-making model of each childcare facility.

3.1 Setup

Consider an economic problem where the supply agent of each childcare facility determines the capacity of the facility. Here, we assume that the production technology of each facility can be represented by a Cobb-Douglas type production function as follows[4]:

$$q = AL^{\alpha}K^{\beta}, \ \ \alpha > 0 \ \text{ and } \ \beta > 0 \tag{1}$$

where q is the capacity of the facility, L is the childcare worker, which is the production factor, K is the capital such as land and facilities, and A is the productivity parameter that is assumed to be smoothly distributed. For simplicity, I will organize the problem as a static model that cuts out decisions such as deciding the capacity of a facility each period. In addition, since the size of the facility and the size of the land cannot be easily changed, we will consider a short-term problem with K fixed, i.e. $K = \bar{K}$.

The problem of each facility will be organized in two stages: cost minimization and profit maximization. Initially, taking production technology as the place and assuming diminishing

[3]Recent developments in the bunching method are reviewed by Kleven (2016).

[4]Previous studies have pointed out that a Cobb-Douglas type production function can be applied to childcare centers (Mocan, 1997).

returns to scale[5], the solution to the cost minimization problem can be expressed as follows[6]:

$$c(q;\theta) = \theta q^{\gamma}, \tag{2}$$

$$\theta \equiv wA^{-\gamma}\overline{K}^{-\beta\gamma} \;\; and \;\; A \sim F(A), \tag{3}$$

where $\gamma \equiv \frac{1}{\alpha}$, and θ is a function of productivity and fixed capital. Given the parameters of the production technology, the minimum cost of supplying a given capacity is calculated. Then, with the cost function obtained in this way known, each facility chooses its capacity so that it maximizes short-term profit:

$$\max_{q} \;\; \pi(p,q;\theta) = pq - \theta q^{\gamma}, \tag{4}$$

where p is the unit cost of childcare. It should be noted that we do not take into account the entry/exit problem regarding the supplier of childcare facilities. We also do not consider the strategic behavior of facilities within the same municipality to determine their own capacity by observing or anticipating the capacity of other facilities. Despite these limitations to the model for the sake of simplicity, we believe that the main theoretical implications of decision-making under nonlinear constraints will not be significantly different.

3.2 Optimization with a constant unit cost of childcare

To begin, we consider optimization when there are no discontinuous jumps in the unit cost of childcare. By solving the first-order condition for optimization, the optimal capacity at each facility is determined, given the capital of the facility and other factors:

$$p - \theta\gamma\hat{q}^{\gamma-1} = 0 \tag{5}$$

$$\Leftrightarrow \hat{q} = \left(\frac{p}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}. \tag{6}$$

[5]We assume diminishing returns to scale for the following reasons: First, anecdotally, as the number of children in a facility of the same size increases, additional staff will be needed to provide support, and thus more labor costs will be incurred. Second, the number of children cared for by each childcare worker decreases as the size of the facility increases (Figure A1). While this is only an observed relationship and does not necessarily reflect the underlying production technology, we believe that our assumption of diminishing returns is not that far off the mark.

[6]Since we are considering short-term profit maximization after entry, fixed costs are not considered here.

The optimal production scale; that is, the childcare center capacity, could be expressed as a function of the unit cost of childcare and the capital, productivity, and production technology parameters. Let us examine how each of these factors affects the optimal scale. First, an increase in the unit cost of childcare increases the optimal capacity. In other words, the capacity of each facility can be changed by moving the subsidy and the unit cost of childcare. The next factor is the productivity component, which includes fixed capital, and the higher the value of this parameter, the higher the cost of caring for each child. In other words, the larger the unobservable productivity, A, or the more capital the facility has, the larger the optimal capacity will be. The last parameter, γ, determines how much the capacity moves in response to a change in the unit cost of childcare. Specifically, $\frac{1}{\gamma-1}$ can be interpreted as the elasticity of supply in relation to the unit cost of childcare, indicating the percentage change in the optimal capacity of each facility when the unit cost of childcare increases by one percent. The closer γ is to 1, the more elastic is the supply of childcare relative to the unit cost.

3.3 Optimization with a step-wise unit cost of childcare

We next consider the optimization problem when a step-wise unit cost of childcare is introduced, as shown in Figure 3. For the sake of simplicity, we discuss here the case of a single discontinuous threshold without any loss of generality. Suppose now that the government introduces a system in which the unit cost of childcare decreases discontinuously at $\bar{q}$,

$$p = \begin{cases} p_0 & if\ q \leq \bar{q} \\ p_1 & if\ q > \bar{q} \end{cases} \tag{7}$$

where $p_1 < p_0$. When each facility chooses a capacity that does not exceed the threshold of $\bar{q}$, a higher unit cost for childcare, p_0, will be applied, and when the capacity exceeds $\bar{q}$, a lower unit cost for childcare, p_1, will be applied. Then, the optimization problem at each facility can be rewritten as follows:

$$\max_q \ \pi(p, q; \theta) = p_0 q + (p_1 - p_0) q \cdot 1\{\bar{q} < q\} - c(q; \theta). \tag{8}$$

We will consider the optimization problem when the objective function of each facility is expressed as equation 8. Since we need to distinguish several cases here, we proceed to solve the optimization accompanied by some conceptual graphs to aid in understanding. Figure 5 illustrates the relationship between the marginal cost curve and the unit cost of childcare in a facility with a certain productivity, θ. The marginal cost curve has a right ascendant shape with respect to capacity, and the assumption is that increasing the size of the facility will make it more costly. In Figure 5a, the productivity is sufficiently low and the marginal cost is high, so the optimal capacity of the facility is not more than the threshold, $\bar{q}$. In this case, the optimal capacity is that at which the marginal cost curve and the unit cost of childcare intersect. When productivity is slightly higher, some facilities reach the optimal capacity at the threshold value of $\bar{q}$ (Figure 5b):

$$\hat{q} = (\frac{p_0}{\bar{\theta}\gamma})^{\frac{1}{\gamma-1}} = \bar{q}. \tag{9}$$

When productivity is higher than that, there are facilities for which the point where the marginal cost curve and the unit cost of childcare intersect under p_0 exceeds the threshold value of $\bar{q}$ (Figure 5c). For these facilities, there is no point at which the marginal cost curve and the unit cost of childcare p_0 intersect when capacity exceeds the threshold value of q. Similarly, these facilities cannot choose a capacity where the marginal cost curve and the unit cost of childcare intersect under the low unit cost of childcare p_1. As a result, to maximize profits, it is optimal to pick the capacity at the threshold where the unit cost of childcare exceeds the marginal cost (Figure 5d). Next, in the case where the marginal cost is low (Figure 5e), there will be facilities where the profit will be equal whether the threshold q is selected or whether capacity is instead selected such that the marginal cost and the unit cost of childcare intersect under the low unit cost of childcare p_1[7]:

$$\pi(p_1, \hat{q}; \theta^{**}) = \pi(p_0, \bar{q}; \theta^{**}). \tag{10}$$

Such facilities are non-discriminatory regardless of which capacity is chosen. Finally, for facilities with even lower marginal costs, it will be optimal to accept a large number of children under a low unit cost of care p_1. The result of such an optimization can be summarized as follows.

$$\hat{\hat{q}} = \begin{cases} (\frac{p_1}{\theta\gamma})^{\frac{1}{\gamma-1}} & if\ \ \theta \leq \theta^{**} \\ \bar{q} & if\ \ \theta^{**} < \theta < \bar{\theta} \\ (\frac{p_0}{\theta\gamma})^{\frac{1}{\gamma-1}} & if\ \ \bar{\theta} \leq \theta. \end{cases} \tag{11}$$

[7]Since $\pi(q;\theta)$ is monotonically increasing in θ, we can find θ^{**} such that $\pi(p_1, \hat{q}; \theta^{**}) = \pi(p_0, \bar{q}; \theta^{**})$

We can thus solve the optimization problem for each facility when a discontinuous unit cost of childcare schedule is introduced, with the most important theoretical implication being that there will be a bunching of facilities that choose a threshold value of $\bar{q}$. This will include facilities with marginal cost curves that lie between those where the marginal cost function and the high unit cost of childcare intersect at threshold $\bar{q}$ as well as those in which the profit is equal under either unit cost of childcare who will choose threshold q as a result of their optimization decision. This results in a distribution of facility capacity as shown in Figure 6 whereby a density mass occurs at a threshold $\bar{q}$, followed by a density hole. If the predictions of economic theory are correct, the actual distribution of childcare center capacity should also have a shape similar to that shown in Figure 6. In the next section, we will verify our predictions using actual data.

A further key theoretical implication is that the size of such a density mass is determined by γ, which determines the elasticity of supply with respect to subsidies. As can be seen in Figure 5e, it is the shape of the marginal cost curve that determines the productivity range that leads to accumulation at threshold $\bar{q}$. It can be seen that once the distribution of productivity is given, the only parameter that determines its shape is γ, which is the parameter that determines elasticity. This indicates that the observed size of the density mass contains information to identify γ. Prior studies have estimated the elasticity of labor supply with respect to wages and the elasticity of hospital acceptance of subsidies by giving nonparametric or parametric distributions for productivity and other heterogeneities. We use a similar approach here to learn about the important parameter, γ, from the degree of bunching.

4 The data and graphical evidence

In this section, we explain the data used to test the theoretical predictions and estimate the structural parameters of the childcare facilities' capacity decisions under a nonlinear subsidy design. We will also examine whether the predictions of the theoretical model in the previous section hold using real-world data from actual childcare facilities, along with descriptive statistics using graphs.

4.1 The data

In this study, we use micro data from the Survey of Social Welfare Institutions (SSWI), a comprehensive survey of public social welfare facilities in Japan conducted by the Ministry of Health, Labor and Welfare (MHLW). SSWI is conducted every October for all accredited childcare centers as well as other public social welfare facilities. Each childcare facility's capacity, the number of children accepted, the area of the facility, and the number of childcare workers are surveyed. Our analysis uses SSWI data from 1993-1997, which is from a period just before various policies related to the expansion of childcare centers were implemented in earnest, such as deregulation and expansion of subsidies, and thus we can estimate pure structural parameters that are not affected by such institutional and policy changes[8].

Table 1 shows the descriptive statistics for each year of the survey in our analysis sample. For each year, the average capacity is around 85 children, which is the average size of a childcare facility in Japan. The number of children actually using the center is around 75, and the number of users has been increasing slightly over the years. This is consistent with the fact that the number of people using childcare centers was increasing during this period (Fukai, 2017). In addition, the number of children actually using childcare centers was slightly lower than the capacity, indicating that while there were children waiting for admission, there was not necessarily excess demand on a nationwide scale[9]. Looking at the number of children using childcare centers by age, the age structure is such that the number of users increases as the children age from 0 to 3, and then stabilizes at around 18 users per facility between the ages of 4 and 5. This is explained by two factors: one on the demand side, where parents start using childcare facilities after their children have grown up to a certain extent, and the other on the supply side, where infants between the ages of 0 and 2 could not be accepted in large numbers because of the high labor and other costs. The average number of childcare workers in each facility is about 10, and the number of workers has been increasing slightly in line with the increase in the number of users. The total floor area of the buildings in the facilities is roughly 600 square meters, and the fact that the area in 1994 and 1997 is almost the same supports the

[8]If we use data from 1998 onward, entry and exit caused by deregulation, as well as other problems that are not taken into account in our model, become more pronounced.

[9]This is partly due to the fact that although there was room to accept toddlers aged 3 and above, there were not enough places to accept infants aged 0-2. Therefore, it is important to point out that a simple comparison between the number of places available and the number of children admitted cannot accurately measure the degree of tightness in supply and demand.

validity of our assumption that capital is fixed in the short term[10].

4.2 Graphical evidence

Figure 7 shows the distribution of childcare center capacity constructed from actual data, along with the accumulated amount of the childcare unit cost for each capacity. As can be seen immediately, there is indeed a concentration of facilities at the capacity thresholds where the unit cost of childcare decreases discontinuously. In particular, we can see that there is a very large bunching at 60 and 90 slots, where the decrease in the unit cost of childcare is large. This distribution is consistent with the theoretical discussion in the previous section, which predicts that facilities will concentrate at thresholds. In other words, in the actual real-world operations of childcare centers, the discontinuous decrease in the unit cost of childcare reduces the incentive to accept children beyond the threshold level. Thus, even though the centers could have accepted more children, they remain at the threshold level. We note that there are several density masses other than at the thresholds when we look at the capacity distribution. This is probably due to the effect of rounding of capacity to multiples of 5 or 10. While the threshold for the change in the unit cost of childcare is also a round number, the impact of rounding seems to not be as large here as the density mass for a rounded number of slots not at the thresholds.

We further examined whether the above-mentioned bunching of the childcare center capacity is also effective for the actual number of children enrolled, and this is shown in Figure 8. Again, the graph is shown along with the accumulated amount of the unit cost of childcare for each capacity, and we again see that bunching occurs at points where the unit cost of childcare falls discontinuously. In other words, the institutional design of the unit cost of childcare itself provides incentives for facilities to remain at the threshold level, and this has a real-world impact on the number of children who can actually use existing childcare centers.

We also see some density masses slightly above the thresholds (particularly, 60 and 90 slots), but this is due to the flexible operation of capacity. During this period when the demand for childcare centers was expanding, facilities were allowed to accept more children than the capacity if there was an excess demand, as long as it was only an additional 10 percent of capacity after meeting the operational standards. In this case, even if the number of children

[10] Since the area of buildings is surveyed only once every three years, we do not have information on the floor area in 1993, 1995 and 1996.

accepted exceeded the threshold, the childcare unit cost before the threshold was applied. This is why we can observe a thickening of the fraction of the number of children using the centers up to about 10 percent more than the threshold. This is also evidence that even though each facility could have actually accepted a few more children, they did not officially set a larger capacity in order to avoid a decrease in the unit cost of childcare.

Lastly, we check that the observed bunching distribution of capacity is not an artifact of the distribution of facility floor area. If facility floor area is distributed in such a way that the threshold capacity is optimally sized, then the observed capacity distribution may merely be a consequence of the facility area distribution. As can be seen from Figure A2, however, the distribution of facility floor area is smooth, though with a slightly thicker right tail. This indicates that the facility area distribution is not what is driving the bunching of facilities at the unit cost of childcare thresholds shown in Figure 7.

5 Empirical evidence

Our descriptive analysis has shown that, consistent with the theoretical predictions, facilities are likely to bunch at a capacity threshold before a discontinuous decline in the unit cost of child care. From the discussion in Section 3, the size of the bunch contains information to identify the elasticity of supply with respect to the unit cost of child care. Therefore, by estimating the model, we actually estimate the structural parameters in the production technology of child care facilities. Then, using those estimated structural parameters and the model, we can conduct a policy simulation of how the supply of childcare services will change when the current childcare unit cost scheme is changed.

5.1 Empirical strategy

Several methods have been proposed for estimating structural parameters using density mass. These include a non-parametric approach that does not assume a specific functional form for heterogeneity such as productivity, and a parametric approach that specifies the functional form. As estimation with parametric assumptions on the distribution of heterogeneity, as in Einav et al. (2017), makes it easy to perform policy simulations with structural parameters, we will take such an approach in this paper as well.

In the actual estimation, the following function is estimated based on the theoretical model in Section 3:

$$c(q;\theta) = \theta q^{\gamma},$$
$$\theta \equiv wA^{-\gamma}\overline{K}^{-\beta\gamma} \ \ and \ \ A \sim LogN(\mu, \sigma) \tag{12}$$

Here, we assume that A, which indicates productivity, follows a log-normal distribution that is relatively flexible in shape. The area of the facility, $\bar{K}$, is given by the distribution in the actual data. For childcare worker wages, the average wage of childcare workers actually observed is given from the Basic Survey on Wage Structure. The remaining parameters, γ and β, which are related to production technology, and μ and σ, which are related to the distribution of productivity, are to be estimated.

Estimation is performed using the simulated method of moments (McFadden, 1989). Using the schedule of childcare unit costs shown in Figure 3 and the cost function in equation 12, the objective function 8 is solved to simulate the optimal capacity. The parameters are estimated so that the results of the simulation can reproduce the magnitude of the density mass that is actually observed. To identify parameters related to production technology, we use the magnitude of the density mass at a threshold capacity where the unit cost of childcare varies discontinuously. In addition, to identify productivity-related parameters, we use the mean and variance information of the actual capacity of the childcare centers. In other words, a total of eight moments are used to estimate the parameters: six moments for the density mass and two moments for the distribution of the childcare capacity. Since the estimation of four parameters using eight moments results in over-identification, the variance-covariance matrix of the moments calculated by bootstrap is used as the optimal weight (Gourieroux et al., 1993).

5.2 Estimated results

The parameters estimated by the simulated method of moments are summarized in Table 2. The coefficients and standard errors calculated by bootstrapping are listed, and indicate that each parameter has been precisely estimated. Since the estimated γ, the parameter indicating the elasticity of supply with respect to the unit cost of childcare, is 6.4, this means that the elasticity value is 0.18. In other words, a 1 percent increase in the unit cost of childcare will result in a 0.2 percent increase in the capacity of childcare centers. Although the magnitude of the elasticity value is not so large, it certainly shows that each facility is sensitive to the unit cost of childcare.

We now check how well our estimation results reproduce the distribution of the actual childcare center capacity. Figure 9 shows the cumulative probability distribution of the actual childcare capacity (solid line) and the distribution of the capacity obtained from the simulation using the estimated parameters (dashed line). The two distributions are quite similar, indicating that the model we are using, although fairly simple, is able to reproduce the actual distribution of capacity very well. We have also checked the histogram (Figure A3), and the only major difference between the actual distribution and the simulation distribution seems to be that we are not able to reproduce the tendency to cluster around a round number such as 5 or 10.

We finally check the distribution of the capacity of childcare centers when the unit cost of childcare is not staircase-like. Figure 10 shows the capacity distribution when the unit cost of childcare is constant regardless of the facility size. Here, we assume that the unit cost of childcare is 54,100 yen per child per month, which is the unit cost applicable to the average childcare center capacity. As can be seen from the figure, if there were no discontinuity in the unit cost of childcare, the distribution of childcare centers would be smooth. The density mass at the threshold disappears, and the distribution is shaped in such a way that it corresponds to the distribution of facility floor area (Figure A2).

5.3 Policy experiment 1: Smooth unit cost schedule

We now proceed to conduct a counterfactual policy simulation by using the estimated parameters and model. To begin with, we are interested in examining the extent to which the discontinuous staircase design of the unit cost of childcare generates losses by distorting the decision-making process of the childcare service suppliers. Therefore, we simulated the total capacity and total unit cost of a childcare center when the staircase-shaped cost schedule was changed to a curve approximated by a smooth quadratic function.

The results of the simulation are shown in Figure 11. We find that by simply making the unit cost schedule smooth in shape, the total capacity of childcare centers could be increased by 3 percent while saving 2 percent in total unit costs. Since half of the total unit cost of childcare is covered by government subsidies and the other half by users, simply eliminating the discontinuity in the unit cost of childcare would allow more children to use childcare centers while reducing the financial burden on governments and users. Thus, the discontinuous schedule of childcare unit costs alone seems to produce economically inefficient results by distorting the decision-making process of childcare suppliers.

In addition, the loss of childcare center supply due to this system design has created other lost opportunities. Simply smoothing the design of the unit cost could increase the capacity of childcare centers by 3 percent, which is equivalent to an increase of 0.8 percentage points in capacity per child[11]. According to a back-of-the-envelope calculation using the results of previous studies, an increase of 0.8 percentage points in childcare center capacity per child would result in an increase of 0.024 percentage points in the fertility rate and 0.4 percentage points in the employment rate of mothers with children aged 2 years and 6 months[12]. Although the magnitude of the impact does not seem large, in a society where low fertility is a serious problem that seems intractable, it is an opportunity that cannot be missed. Further, this would also lead to increased tax revenue resulting from the employment of mothers and increased future tax revenue that will result from the births of their children.

5.4 Policy experiment 2: Flat unit cost scheme

In our next policy simulation, we consider designing a flat unit cost of childcare. There are two reasons for considering a flat unit cost. Firstly, the unit cost schedule approximated by a smooth function in the previous simulation is too complicated to be implemented in practice and may incur additional administrative costs. On the other hand, a flat unit cost only requires the same unit cost to be applied to all facilities, so there is no administrative burden and thus is superior in terms of feasibility. Secondly, by repeating simulations under several flat unit cost scenarios, it is possible to make an exploratory assessment of how much the capacity of childcare centers would change under the current cost. Of course, it is also possible to come up with an optimal schedule that takes into account social welfare, but we will leave those

[11] The capacity of childcare slots per child is calculated using the population of children under six years old, 7,226,506, from the 1995 Japanese Census.

[12] As for the impact on the fertility rate, we use the results of Fukai (2017), which shows that a 1-point increase in the capacity of childcare centers per child results in a 0.03-point increase in the fertility rate. As for the impact on the employment rate, we use the results of Yamaguchi et al. (2018a), which show that a 1-point increase in the capacity of childcare centers per child leads to a 0.76-point increase in the use of childcare centers, and a 0.66-point increase in the employment rate of mothers with children aged 2 years and 6 months who use childcare centers.

issues for the future. By running the simulation in a simpler form here, we hope to make the implications of our analysis easier to grasp.

The following procedure is used to simulate a fixed childcare unit cost. First, the childcare unit cost is set in increments of 1 yen in the range of 10,000 yen to 100,000 yen. Then the optimal number of seats for each facility are similated under each childcare unit cost, based on the estimated parameters. By summing up the optimal capacity of each facility, the total childcare center capacity under a fixed childcare unit cost can be determined. Finally, the total childcare center capacity under all unit cost settings will be analyzed.

In this simulation, we draw upon the childcare center operation standards to make the simulation more realistic. For example, under a high unit cost of childcare, it would be optimal for each facility to have a larger capacity. In such a case, unless some restrictions are placed on the capacity of each facility, we will obtain unrealistic results such as cramming children into the facility. Therefore, we incorporate into the simulation the building area standard required per child. In Japan, the minimum area required for an accredited childcare center is 3.3 square meters per child. Therefore, we set a slightly wider range so that each facility can freely choose the capacity of their childcare center as long as the building area per child does not fall below 5 square meters.

The results of the simulation under the fixed childcare unit cost are shown in Figure 12. In the simulation, the total capacity (Figure A4a) and the total childcare unit cost (Figure A4b) are calculated from the respective optimal childcare center capacities from 10,000 yen to 100,000 yen. Figure 12 shows the relationship between the total capacity (horizontal axis) and the total childcare unit cost (vertical axis) under each childcare unit cost[13]. To clarify the impact, the actual capacity of childcare centers and the total childcare unit cost are also indicated with a cross. The result indicates that in order to achieve the actual capacity of childcare centers in Japan, it would be possible to reduce costs (by about 20 percent) more under a flat childcare unit cost. Alternatively, we could expand the capacity of childcare centers somewhat more within our current budget. This suggests that the design of the unit cost of childcare plays a significant role in the supply of childcare centers, and may provide a new solution to the

[13]Note that the total childcare unit cost progressively increases in relation to the capacity due to restrictions regarding the building floor area. In a facility with a relatively small building area, the maximum capacity that can be selected under a certain childcare unit cost is reached, and it is not possible to select a larger capacity. As a result, even if the unit cost of childcare is increased, it is difficult to increase the number of seats even with a more favorable high unit cost of childcare.

problem of waiting lists for childcare admission.

5.5 Caveats

Our policy simulations have shown that it is possible to increase the supply of childcare centers without increasing costs by changing the setting of the unit cost of childcare, but we would like to point out that there are several shortcomings in our simulations. First of all, they do not take into account changes in the labor demand for childcare workers associated with increasing the capacity of childcare centers. Since the labor demand will change as the scale of childcare centers expands, it can be expected that the wages of childcare workers will also increase. Such an increase in wages may raise the marginal cost and make it difficult to expand capacity. Secondly, the demand side of childcare is not taken into account. As shown in Fukai (2017), the excess demand for childcare is concentrated especially in urban areas, while there is no need to increase capacity in some other areas. This heterogeneity in childcare demand by region is not taken into account in the simulation, and thus decisions are made to increase capacity even in regions where there is no need to increase capacity.

Given these shortcomings, it is fair to say that the results of our simulation capture the upper limit of the effect of changing the unit cost of childcare. However, even so, we believe that the design of the childcare unit cost will have a non-negligible impact on the supply of childcare centers. Future work should include simulations that take into account the above-mentioned heterogeneity of labor demand and childcare demand by region.

6 Conclusion

These days when it is generally recognized that it is important to balance work and family life, both in welfare terms and consequently in terms of national finances, how to provide public social welfare services efficiently has become an emerging issue. In particular, the provision of childcare facilities, which have various positive spillover effects on mothers' employment, fertility and children's development, has continued to attract attention in recent years because of its superior cost-benefit characteristics (van Huizen et al., 2019). A major issue in this context is the lack of sufficient supply to meet the growing demand for childcare (Bauernschuster and Schlotter, 2015; Asai et al., 2015; Fukai, 2017). In these discussions, expanding childcare supply in developed countries, especially in Europe and Japan, is recognized as a challenge due to the difficulty of building new facilities. However, the discussion so far has focused on building new facilities, and not on the public system itself. In particular, public childcare services are often heavily subsidized (OECD, 2019), but how these subsidies are allocated and how they are used has not been sufficiently analyzed. In this paper, we have pointed out for the first time that a more efficient use of existing facilities obtained via a review of the system design is another means of solving the problem of under-supply of childcare services.

In this study, we estimated the critical structural parameters for the supply of childcare services and conducted policy simulations by scrutinizing the institutional design of public childcare services in Japan. Specifically, we focused on the institutional design in which the amount of money each facility receives per child admitted, called the unit cost of childcare and which is funded by government subsidies and user payments, falls discontinuously with the size of the facility, and used this bunching to estimate the structural parameters related to production technology. The discontinuous decrease in the unit cost of childcare creates an incentive to not further increase the size of the facility, which leads to a concentration of facilities at the threshold. This degree of bunching has information that allows us to identify structural parameters that identify the degree to which the supply of capacity is elastic with respect to the subsidy each facility receives. We found that the elasticity of supply with respect to the unit cost of childcare, obtained from these theoretical predictions and the estimation of the model using actual data, was about 0.2. Policy simulations using the estimated parameters show that it is possible to expand the supply of childcare centers while reducing costs by eliminating the unit cost discontinuities and also by using other unit cost settings such as a flat cost. This result provides a new perspective on the usefulness of identifying key production parameters and revising the existing institutional system, rather than merely building new facilities.

There are of course many aspects that we have not taken into account in our analysis, and we would like to point out some here in order to provide direction for future research. First of all, we have not been able to take into account the heterogeneity of the parameters of production technology. It is quite possible that the elasticity of supply with respect to the unit cost of childcare differs depending on the size of the facility (the capital outlay). Another issue is the setting of the objective function. As pointed out in previous studies Blau and Mocan (2002), the providers of childcare services are not only looking for profit, but are also concerned about the quality of the childcare they are providing. These preferences for quality are not taken into account, which may be related to the fact that the elasticities we estimated are not that large. Another related topic is the heterogeneity as to whether the provider is a for-profit or non-profit organization (Mocan and Tekin, 2003; Ito et al., 2015). Thirdly, this paper does not consider dynamic aspects such as entry and exit from the childcare industry and acceptance of children. The simulation results do not reflect the impact of changing the unit cost of childcare on market entry/exit. In addition, other more realistic dynamic aspects, such as the fact that once a child of a certain age is admitted to a childcare facility, the facility will usually continue to admit the child until the child enters elementary school, could be taken into account to obtain deeper policy implications. Finally, by taking into account the demand-side factors of childcare, which are not addressed in this study, it would be possible to estimate and simulate a more realistic model.

While our simple model has various possibilities for development, we would like to emphasize again that this paper is a first step in showing that estimating parameters related to production technology can be very useful. Our contribution in this paper is to show that by presenting data consistent with the unique features of existing institutions and the theoretical implications derived from them, and by making a clean identification of structural parameters, we can obtain a variety of policy implications. We believe that the discussion in our paper can be applied not only to childcare, but also to other public social welfare policies such as public long-term care, which is also heavily regulated, publicly funded, and under-supplied.

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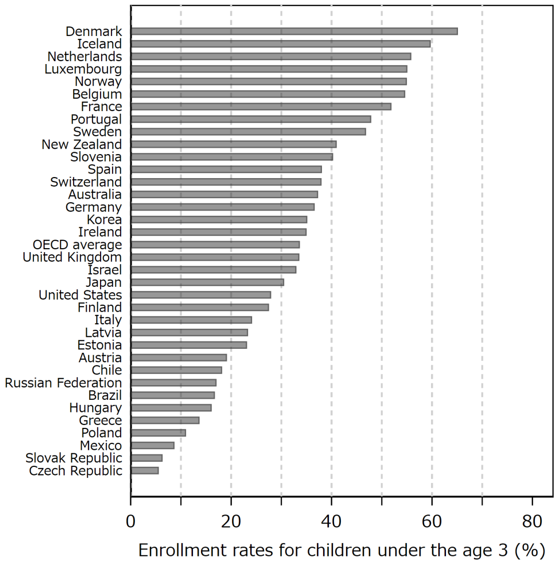
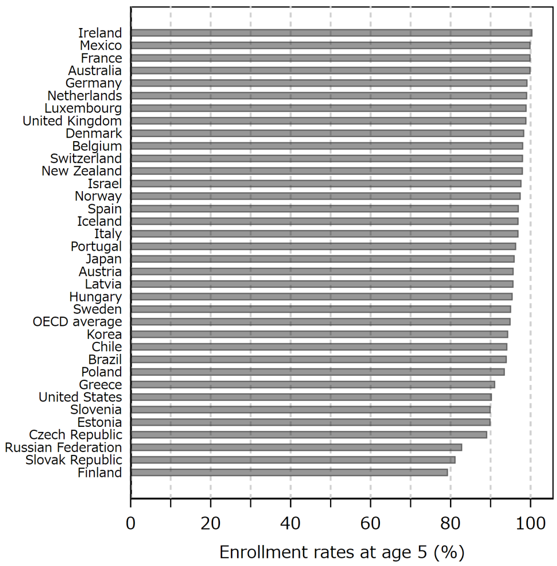
List of Figures



(a) Enrollment rates for children under age 3



(b) Enrollment rates at age 5

Figure 1: Enrollment rates in formal childhood care and primary education, by age (2014)

Source: OECD Family Database, OECD, Paris, http://www.oecd.org/els/family/database.htm and Education at a Glance 2016: OECD Indicators, OECD Publishing, Paris, http://dx.doi.org/10.1787/eag-2016-en.

Note: This figure shows the proportion of children who use childcare facilities in OECD countries, as provided by the OECD database. The graph was prepared by the author using data published by the OECD.

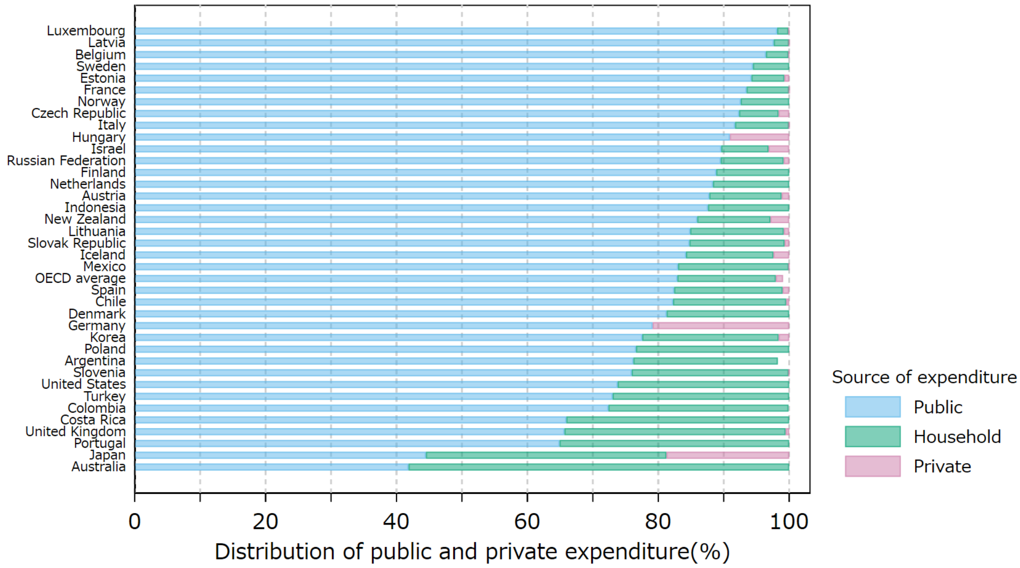


Figure 2: Composition of financial resources for pre-school education (2013)

Source: OECD Online education database, OECD, Paris, `http://www.oecd.org/education/database.htm`.
Note: This graph shows a breakdown of who finances pre-school education in OECD countries, with Public indicating public funding, Household indicating household spending, and Private indicating spending by other private actors, as provided by the OECD database. The graph was prepared by the author using data published by the OECD.

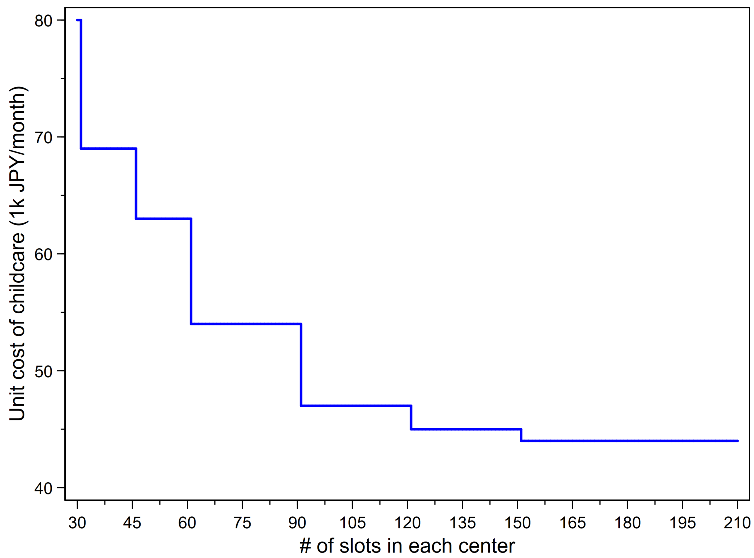


Figure 3: Schedule of the unit cost of childcare

Note: This figure shows the profile of the monthly unit cost of childcare per child and the facility capacity at facilities that care for children, with an average age structure in 1995. The horizontal axis shows the capacity rather than the number of children accepted at each facility

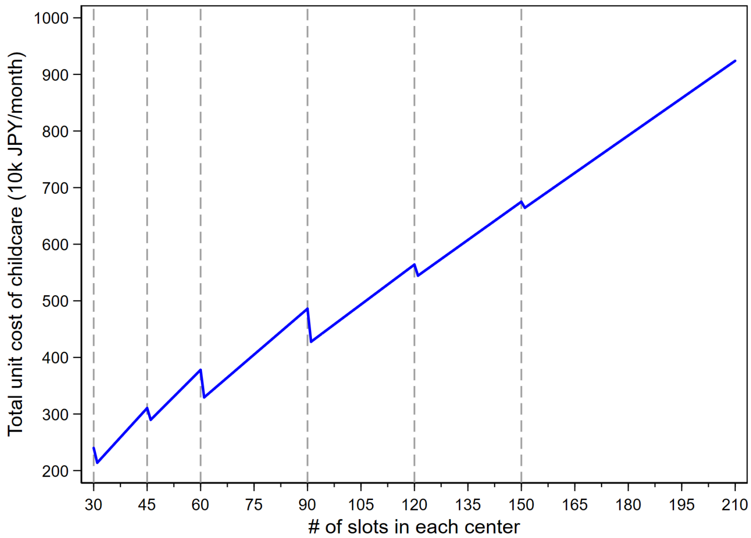


Figure 4: Schedule of total childcare unit costs received by each facility

Note: This figure illustrates the actual operating budget that the facility would receive for each capacity, based on the profile of childcare unit costs in Figure 3. The operating budget here is the sum of the subsidy from the government and the user fees.

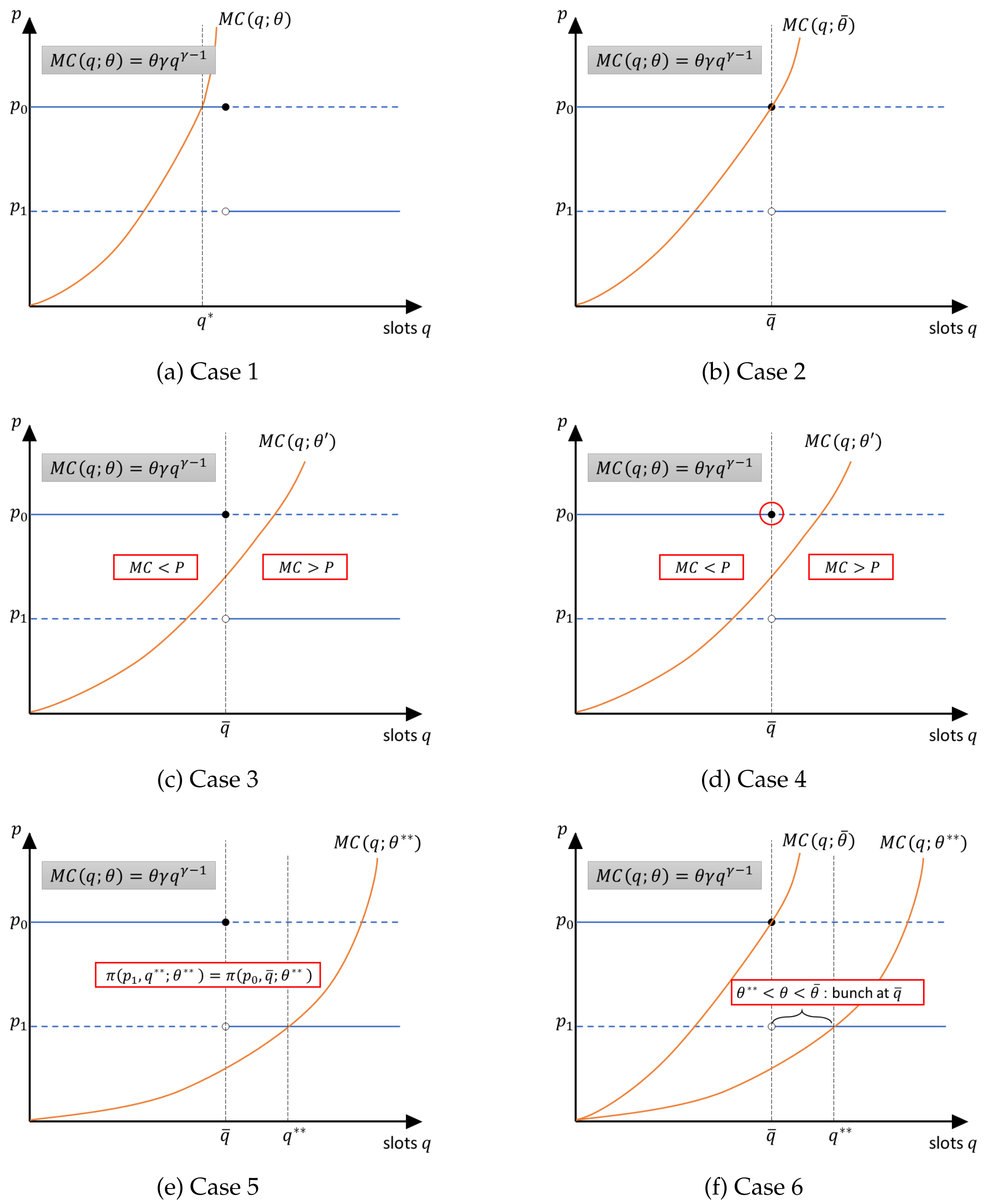


Figure 5: Conceptual diagram for optimization

Note: This figure illustrates the relationship between the marginal cost curve and the unit cost of childcare in a facility with a certain productivity, θ.

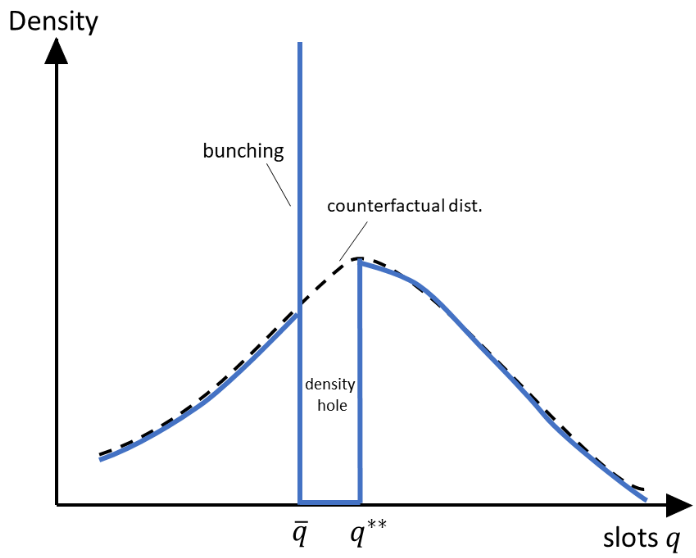


Figure 6: Bunching and density hole created by notch in unit cost of childcare

Note: This chart illustrates the distribution of the childcare center capacity resulting from the discontinuous childcare unit cost. The solid line is the distribution of the capacity under the discontinuous childcare unit cost, and the dotted line is the distribution of the counterfactual childcare center capacity when there was no discontinuity in the childcare unit cost.

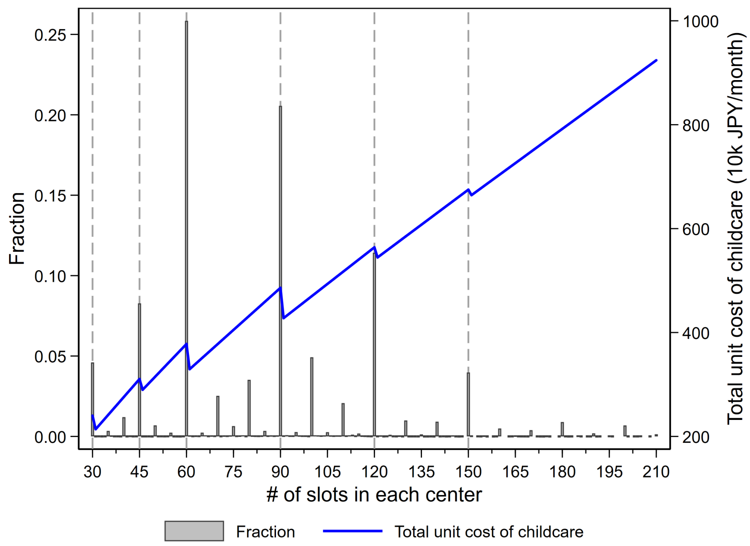


Figure 7: Distribution of childcare slots in each center

Source: The Survey of Social Welfare Institutions (MHLW)
Note: This figure shows the distribution of childcare centers' capacity from 1993 to 1997, along with the accumulated amount of the childcare unit cost for each capacity.

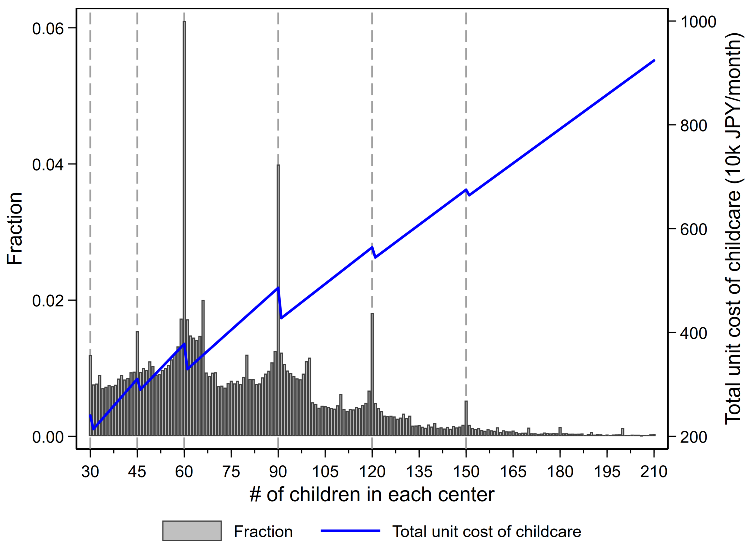


Figure 8: Distribution of number of children enrolled in each center

Source: The Survey of Social Welfare Institutions (MHLW)
Note: This figure shows the distribution of the number of children enrolled in each childcare facility from 1993 to 1997, along with the accumulated amount of the childcare unit cost for each capacity.

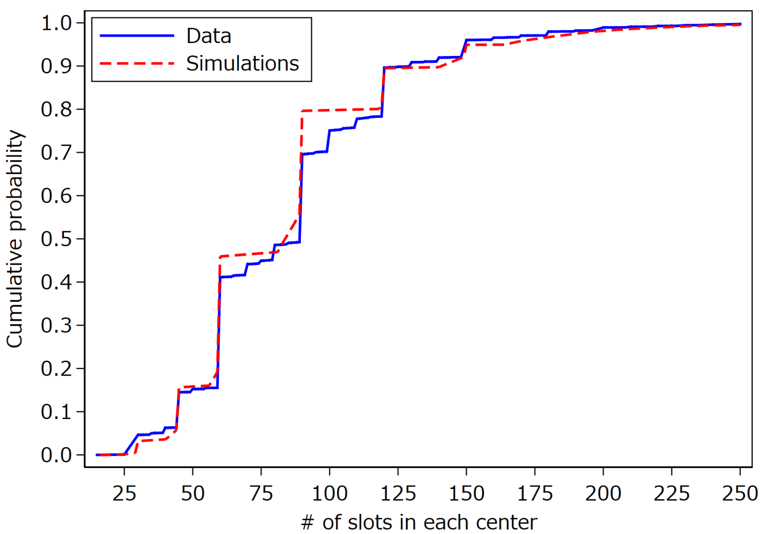


Figure 9: Comparison of the CDF of childcare center capacity on actual data and simulation results

Source: The Survey of Social Welfare Institutions (MHLW)
Note: This figure shows the cumulative probability distribution of the actual childcare capacity from 1993 to 1997 (solid line) and the distribution of the capacity obtained from the simulation using the estimated parameters (dashed line).

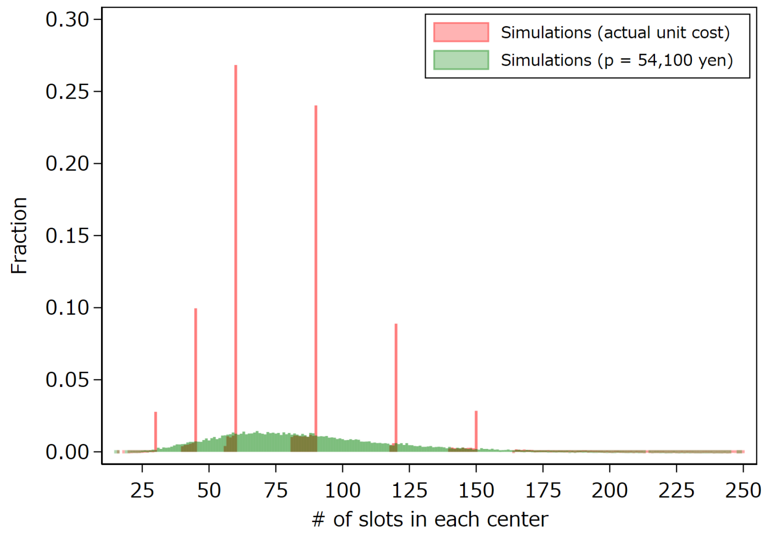


Figure 10: Changes in the distribution of childcare center capacity when discontinuity in child care unit costs is eliminated

Note: This figure shows the distribution of the capacity of childcare centers when the childcare unit cost is constant regardless of the facility size. Here, we assume that the unit cost of childcare is 54,100 yen per child per month, which is the unit cost applicable to the average childcare center capacity.

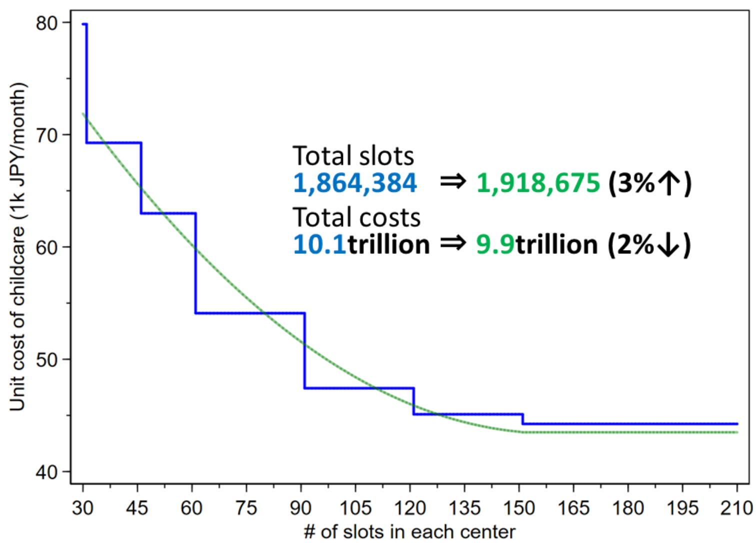


Figure 11: Results of policy simulation under smooth childcare unit cost

Note: This figure shows the simulation results when a step-wise schedule of childcare unit costs is approximated by a smooth quadratic function. The blue line shows the original child care unit cost profile, and the green line shows the approximation by the quadratic function.

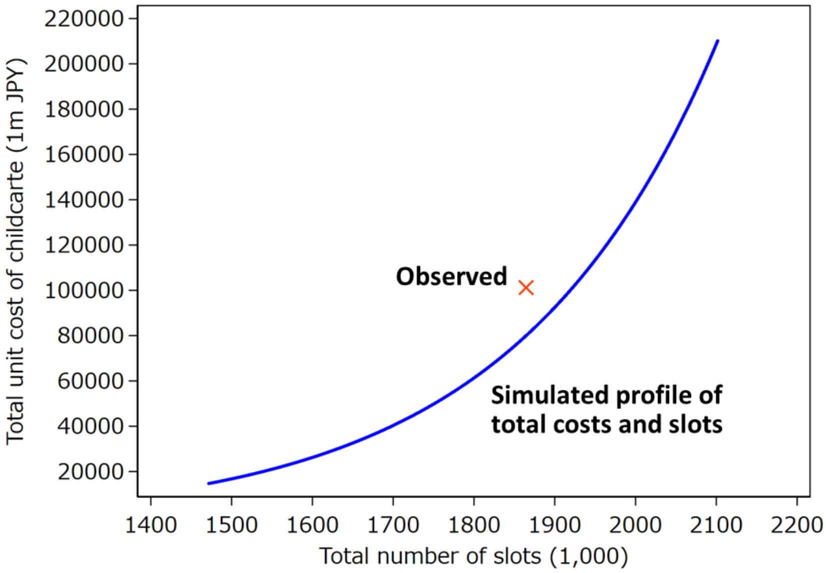


Figure 12: Results of policy simulations under a fixed unit cost of childcare

Note: This figure shows the relationship between the total capacity (horizontal axis) and the total childcare unit cost (vertical axis) calculated from the respective optimal childcare center capacity under unit costs from 10,000 yen to 100,000 yen.

List of Tables

Table 1: Summary statistics

	Year of survey				
	1993	1994	1995	1996	1997
Number of slots	86.2	85.9	85.5	85.4	85.6
	[38.1]	[38.0]	[38.0]	[38.1]	[38.3]
Enrollment: All	74.6	74.4	74.7	75.8	77.7
	[36.5]	[36.6]	[37.0]	[37.6]	[38.7]
Enrollment: Age 0	1.3	1.3	1.4	1.5	1.5
	[2.4]	[2.4]	[2.5]	[2.5]	[2.5]
Enrollment: Age 1	5.2	5.4	5.7	6.1	6.3
	[5.3]	[5.3]	[5.5]	[5.7]	[5.7]
Enrollment: Age 2	8.5	8.7	9.0	9.5	9.8
	[6.4]	[6.5]	[6.5]	[6.7]	[6.8]
Enrollment: Age 3	14.2	14.1	14.4	14.5	15.0
	[8.0]	[7.9]	[8.1]	[8.2]	[8.3]
Enrollment: Age 4	18.3	18.0	17.9	18.2	18.2
	[10.7]	[10.6]	[10.6]	[10.7]	[107]
Enrollment: Age 5	18.3	17.9	17.7	17.7	18.1
	[11.4]	[11.1]	[11.1]	[11.0]	[11.2]
Number of childcare workers	9.5	9.6	9.9	10.3	10.6
	[5.8]	[5.8]	[6.0]	[6.1]	[6.2]
Building floor area of the facility (m^2)	-	606.6	-	-	610.7
	-	[307.2]	-	-	[280.4]
Number of facilities	22,584	22,526	22,488	22,438	22,387

Source: The Survey of Social Welfare Institutions (MHLW).
Note: This table shows descriptive statistics of childcare facilities from 1993 to 1997. We show summary statistics by each survey year, and the means and standard deviations for each variable are shown. Standard deviations are shown in brackets.

Table 2: Estimated parameters

Parameter	Variable	Estimate	S.E.
γ	Determinant of elasticity	6.406	0.097
β	Parameter w.r.t. K	0.370	0.006
μ	Mean of productivity	$0.026(\times 10^{-3})$	$0.010(\times 10^{-3})$
σ	Std. of productivity	2.132	0.031

standard errors are obtained by bootstrap method

Source: The Survey of Social Welfare Institutions (MHLW).
Note: This table summarizes the estimated parameter obtained by simulate method of moments. The estimated parameters and standard errors calculated by the bootstrap method are listed.

Appendix

A Supplementary figures

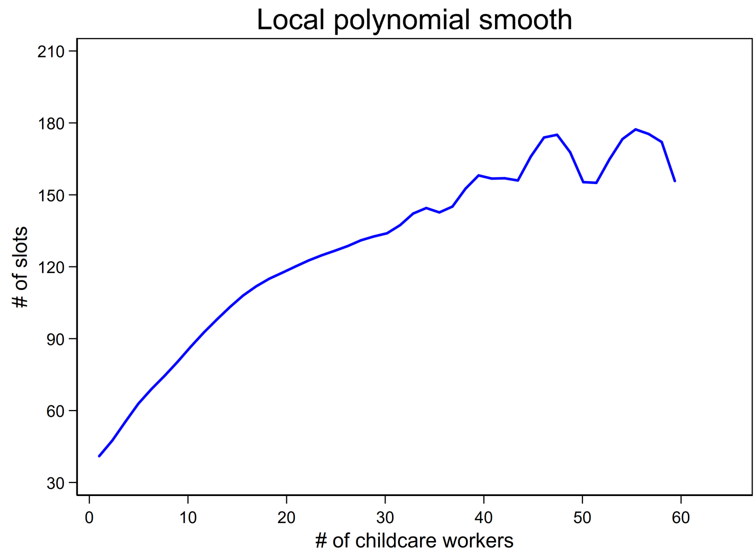


Figure A1: Observed relationship between the number of child care workers and capacity in each facility.

Source: The Survey of Social Welfare Institutions (MHLW)
Note: This figure shows the result of local polynomial estimation of the relationship between the number of child care workers and the capacity of each child care facility from 1993 to 1997.

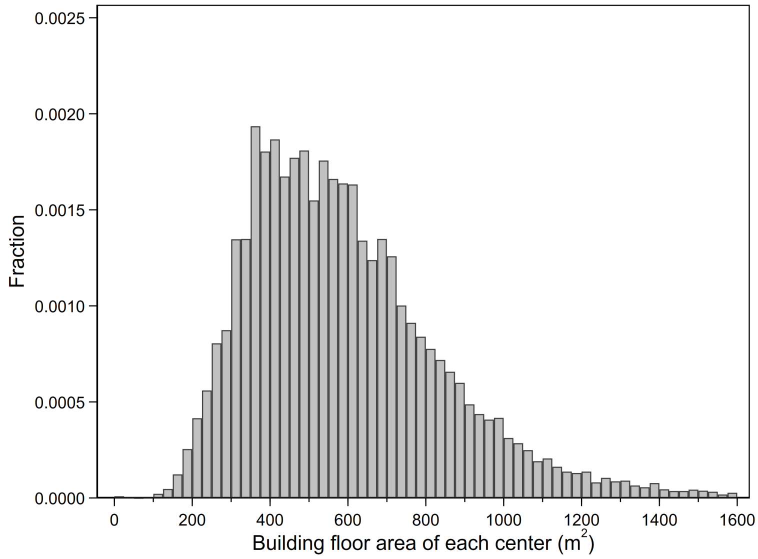


Figure A2: Distribution of building floor area of each center in 1994 (m^2)

Source: The Survey of Social Welfare Institutions (MHLW)
Note: This figure shows the distribution of the floor area of the buildings of each childcare facility in 1994. The histogram is illustrated with a bin of $25m^2$.

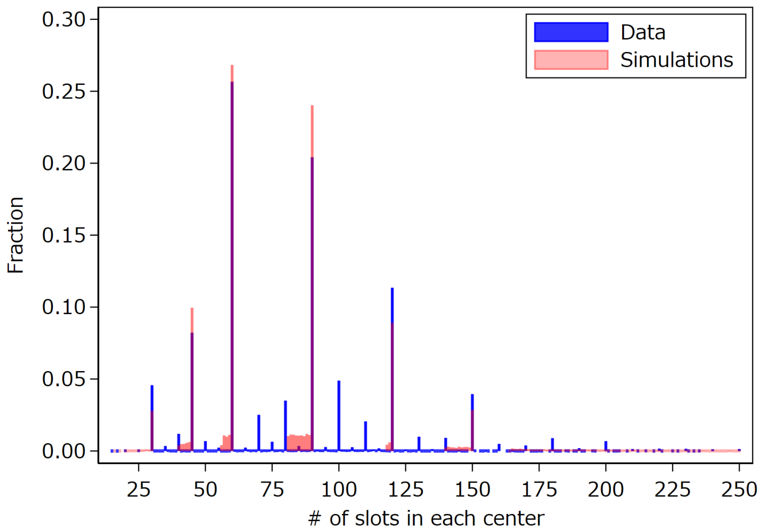
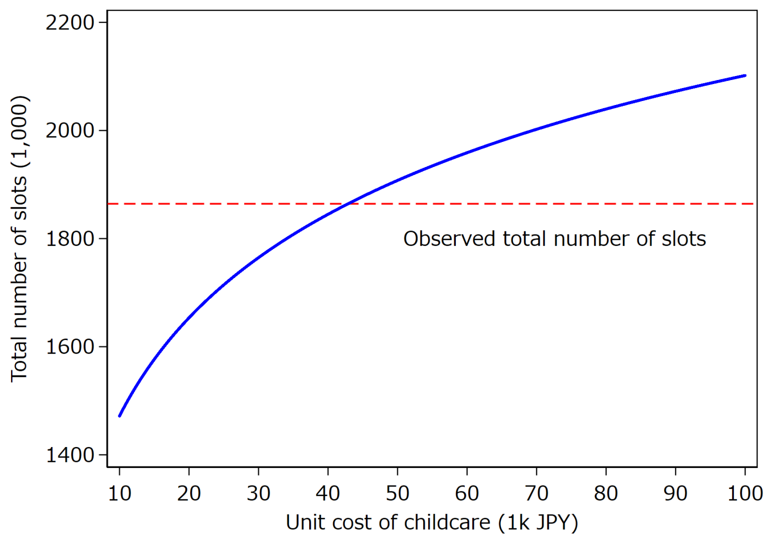
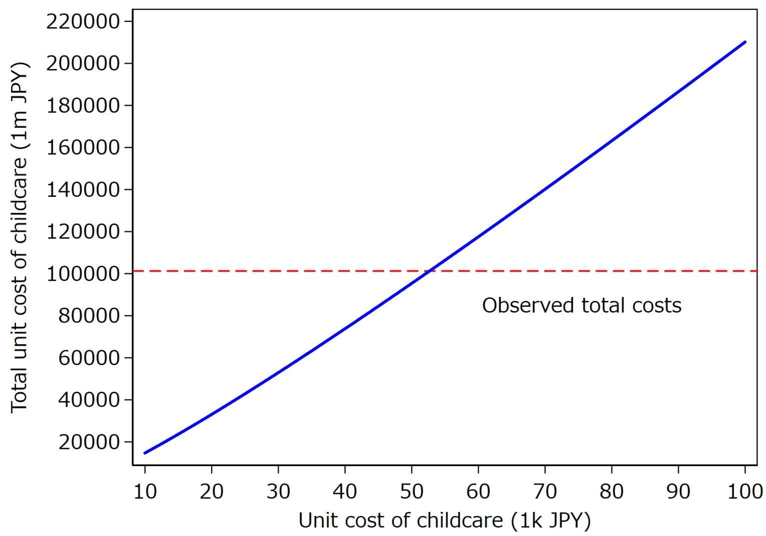


Figure A3: Comparison of the distribution of childcare center capacity on actual data and simulation results

Source: The Survey of Social Welfare Institutions (MHLW)
Note: This figure shows the distribution of the actual childcare capacity from 1993 to 1997 (blue colored) and the distribution of the capacity obtained from the simulation using the estimated parameters (red colored).



(a) Unit cost of childcare and the simulated total childcare center capacity



(b) Unit cost of childcare and the simulated total costs

Figure A4: Results of policy simulations under a fixed unit cost of childcare (details)

Note: This figure shows the simulation results for the total childcare center capacity and total cost profile under each childcare unit cost. The top figure shows the simulated total childcare center capacity under each childcare unit cost setting, and the bottom figure shows the simulated total costs.