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Abstract

In Japan, total elderly care costs continue to increase because of the aging of the population. An overall increase in elderly care costs will raise government expenditures because the elderly care system in Japan is financed mainly with public funds. To reduce elderly care costs, some services exist which reduce the need for elderly care services. For these analyses, we created a model with ordinary elderly care services and services which reduce the need for elderly care to ascertain how these services should best be supplies. The results are as follows: if these two services are provided by different service providers, the reduction in the necessary elderly care service is less than for the case in which that the service is provided by the same provider. Moreover, in order to minimize the total costs of elderly care provide by the government, our paper derives the appropriate remuneration for services that reduce the need for elderly care.

Keywords: Aging Population, Elderly Care Level, Elderly Care Supply, Government Expenditure
JEL classification: J14, J18

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1. Introduction

In OECD countries, the ratio of elderly people rises. Especially, the elderly people ratio in Japan is the highest in the world. As a result, the total cost of elderly care increases. It has reached ten trillion JPY.[1] The elderly care cost should be controlled because an increase in costs requires an increase in taxes and premiums. Then, the household is adversely affected by the burden of an increase in taxes and premiums.

In Japan, services to reduce the level of elderly care are provided to decrease the total amount of elderly care. Seon (2018) explains that some local government provide the incentive reward for decreasing elderly care level. This benefit for prevention is provided by the government. By virtue of the benefit for prevention, the elderly care level is decreased and elderly people can live for themselves without care. Demand for elderly care services decreases. Total costs for elderly care can also be decreased.

Our paper presents examination of whether services to reduce the elderly care level reduce the total elderly care cost or not in the model that includes elderly care services of two types: one for ordinary elderly care service and the other for the services to reduce the elderly care level. Results demonstrate that if the reward of the service to reduce the elderly care level is large in these two services provided by different providers, the total elderly care cost is lower than the case in which these services are provided by the same provider. Moreover, we derive the reward obtained from the service to reduce the elderly care level and to minimize the total elderly care cost.

Many reports of the related literature, such as those by Lundholm and Ohlsson (1998), Tabata (2005), Mizushima (2009), and Cremer and Roeder (2013) describe that the subsidy for elderly care service raises demand for the service. They derive the optimal subsidy level in terms of welfare. White-Means and Rubin (2004), Korn and Wrede (2013), Mou and Winer (2015), and Yasuoka (2019b) examine elderly care of two types: formal care and informal care or family care. They also derive how these services level are determined and examine the substitution between the two types of elderly care. Yasuoka (2019a) examines how the wage rate and the labor share in the elderly care service labor market are determined.

As explained above, studies of many types have been reported. However, few related papers describe how the service to reduce elderly care level decreases total elderly costs. In Japan, reduce the total elderly cost is under consideration and is worth examination in this paper.

The remainder of this paper is arranged as follows. Section 2 sets the model. Section 3 presents examination of the case before separating services of two types. Section 4 elucidates the case after separating services of two types. Section 5 compares results presented in sections 3 and 4. The final section concludes this paper.

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[1] Data: Ministry of Health and Labor, Japan. Data are for 2018.

2. Model

In this model economy, elderly care services of two types exist: one for the ordinary elderly care service (Service 1) and the other for the service to reduce the elderly care level (Service 2).

This model economy includes low and high elderly care levels. The unit reward from the low and high elderly care levels are defined respectively as q^L and q^H, where $q^H > q^L$. This reward is set by the government.

Only elderly people need service 2. The service 2 provider can reduce the elderly care level from high to low with probability $p(e)$. e denotes the input of the service to reduce the elderly care level. The cost function of Service 2 is assumed by $\frac{1}{2}\gamma e^2, (0 < \gamma)$.[2] Probability $p(e)$ is assumed as shown below.

$$p(e) = ae, 0 < a \tag{1}$$

In that equation, $p(e)$ denotes the share of low elderly care level and $0 \leq p(e) \leq 1$ is assumed. If $p(e)$ increases by a unit, then the provider of Service 2 can gain reward β, which is set by government.

3. Before Separating Service 1 and Service 2

In this case, we examine the case in which one provider provides Service 1 and Service 2. We define x as the quantity of supply of Service 1. The cost function of Service 1 is assumed by $\frac{1}{2}mx^2$ $(0 < m)$. Then, the profit function is presented below.

$$\pi = \left(p(e)q^L + \left(1 - p(e)\right)q^H\right)x - \frac{1}{2}mx^2 + p(e)\beta - \frac{1}{2}\gamma e^2. \tag{2}$$

$\left(p(e)q^L + \left(1 - p(e)\right)q^H\right)x - \frac{1}{2}mx^2$ and $p(e)\beta - \frac{1}{2}\gamma e^2$ respectively represent the profit of Service 1 and Service 2. With maximization of profit function (2), one can obtain x as

$$x = \frac{1}{m}\left(p(e)q^L + \left(1 - p(e)\right)q^H\right). \tag{3}$$

x depends on e. Substituting (3) into (2), one can obtain the following profit function:

$$\pi = \frac{1}{2m}\left(p(e)q^L + \left(1 - p(e)\right)q^H\right)^2 + p(e)\beta - \frac{1}{2}\gamma e^2. \tag{4}$$

With maximization of profit function (4), one obtains e as

$$e = \frac{a\beta - q^H(q^H - q^L)\frac{a}{m}}{\gamma - (q^H - q^L)^2\frac{a^2}{m}}. \tag{5}$$

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[2] For simplicity, we assume the quadratic cost function. We can consider other cost function as $\gamma e^{\varepsilon}, (1 < \varepsilon)$. If the cost for service 2 is large for any input, we can consider the case of large γ and ε.

4. After Separating Service 1 and Service 2

In this case, we consider the case in which Service 1 and Service 2 are provided by different providers. Then, the profit function of Service 1 can be shown as

$$\pi = \left(p(e)q^L + \left(1 - p(e)\right)q^H\right)x - \frac{1}{2}mx^2. \tag{6}$$

Optimal x is given as (3). The profit function of Service 2 can be presented as shown below.

$$\pi = p(e)\beta - \frac{1}{2}\gamma e^2 \tag{7}$$

Optimal e to maximize (7) can be represented as

$$e = \frac{a\beta}{\gamma}. \tag{8}$$

5. Comparison of Cases Before and After Separating Services

This section presents comparison of the case before separating services and the one after separating services. With (5) and (8), if the following inequality holds, the service to reduce elderly care level after separating services shown by (8) is greater than the service shown by (5).

$$\beta < \frac{\gamma q^H}{a^2(q^H - q^L)} \tag{9}$$

The following inequality holds. The supply of the service to reduce the elderly care level before separating services is greater than in the case after separating services.

$$\beta > \frac{\gamma q^H}{a^2(q^H - q^L)} \tag{10}$$

Generally, the total profit of Service 1 and Service 2 before separating services is greater than the case after separating services because the externality by which Service 2 negatively affects Service 1 exists. Also, the case before separating services considers the externality in profit maximization.

If e is given as (8), then the probability that the service can reduce the elderly care level from a high level to low level is given as $p_1 \equiv p(e) = \frac{a^2}{\gamma}\beta$. The conditions to have $p_1 \leq 1$ can be expressed as shown below. [3]

$$\beta \leq \gamma / a^2 \tag{11}$$

If reward β is given as shown in (11), then the following proposition can be established.

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[3] (9) is given as $\frac{a}{\gamma}\beta > \frac{a\beta - q^H(q^H - q^L)\frac{a}{m}}{\gamma - (q^H - q^L)^2\frac{a^2}{m}}$. The probability given as (8) can be shown as $p_1 \equiv p(e) = \frac{a^2}{\gamma}\beta$. Also, $\frac{a}{\gamma}\beta < \frac{a\beta - q^H(q^H - q^L)\frac{a}{m}}{\gamma - (q^H - q^L)^2\frac{a^2}{m}}$ is given. The probability given as (5) can be shown as $p_2 \equiv p(e) = \frac{a^2\beta - q^H(q^H - q^L)\frac{a^2}{m}}{\gamma - (q^H - q^L)^2\frac{a^2}{m}}$. Then one can check that $p_2 < p_1$ and $0 \leq p_2 \leq 1$ hold.

Proposition 1 With $\beta \leq \gamma/a^2$, the inequality (10) cannot hold.

Proof We prove the proposition by contradiction. If β holds (10), then we would be able to obtain the following inequality.

$$\frac{\gamma q^H}{a^2(q^H-q^L)} < \beta \leq \gamma/a^2 \Rightarrow q^H + q^L < q^H \Leftrightarrow q^L < 0$$

However, this inequality contradicts $0 < q^L$.[4] (Q.E.D.)

Proposition 1 shows that it need that β always it is necessary that β always holds (9). Then, the supply of the services to reduce the elderly care level after separating services is greater than that before separating services: separating Service 1 and Service 2 is desirable to raise the supply of the service to reduce the elderly care level. Then, the ordinary elderly care service (Service 1) in the case after separating services is less than that before separating services because of (3).

Moreover, after separating services, the service to reduce the elderly care level (Service 2) can reduce the total reward for elderly care paid by the government. We define the total reward for elderly care paid by the government after separating services and that before separating services respectively as G_1 and G_2. If $p(e)$ is given, then the total reward for elderly care paid by the government $(G(p(e))$ is

$$\begin{aligned} G(p(e)) &= \frac{1}{m}\left(q^H - p(e)(q^H - q^L)\right)^2 + p(e)\beta \\ &= \frac{(q^H - q^L)^2}{m}\left\{(p(e) - b)^2 + \left(\frac{q^H}{q^H - q^L}\right)^2 - b^2\right\}, \end{aligned} \quad (12)$$

where b≡ $\left(\frac{q^H}{q^H-q^L} - \frac{m\beta}{2(q^H-q^L)^2}\right)$. Defining $p_1 = \frac{a^2}{\gamma}\beta$ and $p_2 = \frac{a^2\beta - q^H(q^H-q^L)\frac{a^2}{m}}{\gamma-(q^H-q^L)^2\frac{a^2}{m}}$, we can obtain $G_1 = G(p_1)$ and $G_2 = G(p_2)$ because of (12). Because of $p_1 > p_2$ and (12), the following proposition can be established.

Proposition 2 If the reward $\beta < \beta^*$, then one can obtain $G_1 < G_2$. If the reward $\beta > \beta^*$, then one

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[4] Proposition 1 is generalized to nonlinear $p(e)$. Assume that $p(e)$ is weakly increasing and not too convex, as $p'(e) \geq 0$ and $p''(e) < \frac{\gamma}{\beta}$. It is noteworthy that $p(e) \in [0,1]$ always holds. Equation (4) is maximized when

$$\frac{1}{m}(p(e)q^L + (1 - p(e)q^H)p'(e)(q^L - q^H) + p'(e)\beta - \gamma e = 0 \quad \text{(a)}$$

holds. Equation (7) is maximized when

$$p'(e)\beta - \gamma e = 0 \;\; p'(e)\beta - \gamma e = 0 \quad \text{(b)}$$

holds. Because $\frac{1}{m}(p(e)q^L + (1 - p(e)q^H)p'(e)(q^L - q^H) < 0$ holds and $p'(e)\beta - \gamma e$ is decreasing with e, optimized e in equation (a) is always less than that in equation (b).

can obtain $G_1 > G_2$. β^* is defined as shown below.

$$\beta^* \equiv \frac{2\frac{q^H}{q^H - q^L} + \frac{q^H(q^H - q^L)\frac{a^2}{m}}{\gamma - (q^H - q^L)^2\frac{a^2}{m}}}{2\frac{m}{2(q^H - q^L)^2} + \frac{a^2}{\gamma} + \frac{a^2}{\gamma - (q^H - q^L)^2\frac{a^2}{m}}}. \quad (13)$$

Proof $G(p(e))$ is quadratic function of $p(e)$ and convex downward parabola. Therefore, the symmetry axis of this parabola is given as $p(e) = b$ and $p_1 > p_2$. We can obtain the following results.

$$\begin{cases} \text{If } b > p_1,\ G_1 < G_2. \\ \text{If } p_2 < b < p_1 \text{ and } b > \frac{p_1+p_2}{2}, G_1 < G_2. \\ \text{If } p_2 < b < p_1 \text{ and } b < \frac{p_1+p_2}{2}, G_1 > G_2. \\ \text{If } b < p_2,\ G_1 > G_2. \end{cases} \Leftrightarrow \begin{cases} \text{If } b > \frac{p_1+p_2}{2},\ G_1 < G_2. \\ \text{If } b < \frac{p_1+p_2}{2},\ G_1 > G_2. \end{cases}$$

Because of this condition and simple calculation, we can obtain Proposition 2. (Q.E.D.)

The total profit of Service 1 and Service 2 before separating services is greater than the total profit after separating services. The supply of ordinary elderly care service x after separating services is smaller than the supply before separating services. The supply of service to reduce the elderly care level e before separating services is less than the supply after separating services. These results are attributed to the externality. [5] As long as the firm considers the negative externality by which Service 2 decreases the profit of Service 1, the total profit is maximized at the case before separating services. Therefore, it is not good to separate services of two types.

However, if we consider the total reward of elderly care paid by the government, the case after separating services is desirable. In Japan, halting the total reward of elderly care paid by the government is necessary. With $\beta > \beta^*$, the total reward of elderly care after separating services is less than in the case before separating services. A government seeking to reduce the total reward of elderly care should separate the services, depending on the value of β.

The total reward of elderly care service paid by the government after separating services can be represented as shown below.

$$H = \left(p(e)q^L + \left(1 - p(e)\right)q^H\right)x + p(e)\beta = \frac{\left(q^H - \frac{(q^H - q^L)a^2}{\gamma}\beta\right)^2}{m} + \frac{a^2\beta^2}{\gamma} \quad (14)$$

The value of β to minimize the total reward of elderly care service can be derived as $\beta =$

[5] Integration of each service sector internalizes the externality. The total profit of service sectors is maximized. However, even if the service sector is separated, one can obtain the result that a decrease in reward after separating service sector β makes e reach the level before separating the service sector.

$\frac{\gamma(q^H-q^L)q^H}{\gamma m+(q^H-q^L)^2a^2}$ because of $\frac{\partial H}{\partial \beta}=0$.[6] An increase in m and a or a decrease in γ reduces β to hold $\frac{\partial H}{\partial \beta}=0$. An increase in m means an increase in cost for service 1. An increase a raises the population share of low level of elderly care. If the population share of low level of elderly care is small, large level of β is inefficiency in terms of a decrease in the population share of high level of elderly care. An increase in (q^H-q^L) does not always raise β to hold $\frac{\partial H}{\partial \beta}=0$.[7] If γ or m is large, β to hold $\frac{\partial H}{\partial \beta}=0$ is large. That is, if the cost of elderly care of service 1 and 2, the subsidy for service 2 can be efficient to cut the total reward of elderly care service.

6. Conclusion

This paper sets the model with two types of elderly care services: one for the ordinary elderly care service and the other for the service to reduce the elderly care level. Then we examine how the supply of services of two types is determined before and after separating the two services. Results show that the supply of service to reduce the elderly care level after separating services is greater than in the case before separating services if the reward for the service to reduce the elderly care level is greater. The ordinary elderly care service is smaller than in the case before separating services. The total profit of two types of services before separating services is greater than in the case after separating services.

However, the total cost of elderly care services after separating services is less than in the case before separating services if the reward for a unit of service to reduce the elderly care level is greater than a certain level. This result demonstrates that the government can control the total cost of elderly care services. Taken together, the results obtained from this study indicate that the government must set the reward system of elderly care service and must devote consideration to how elderly care services should be managed.

6 If we consider the case of integrated service, we can obtain $\beta = \frac{(q^H-q^L)q^H\left(1+2\left(1+\frac{(q^H-q^L)^2a^2}{\gamma m-(q^H-q^L)^2a^2}\right)\right)}{2m\left(1+\frac{(q^H-q^L)^2a^2}{\gamma m-(q^H-q^L)^2a^2}\right)}$ as $\frac{\partial H}{\partial \beta}=0$.

7 With differentiation of $\frac{\partial \frac{\gamma(q^H-q^L)q^H}{\gamma m+(q^H-q^L)^2a^2}}{\partial(q^H-q^L)}$, we can obtain $\frac{\gamma m-(q_H-q_L)^2a^2}{(\gamma m+(q_H-q_L)^2a^2)^2}$.

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