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1. Introduction and methods

As the number of the elderly increases rapidly in Japan, long-term care services are increasingly needed. The growth of the consumption of long-term care services is often taken to be the growth of reimbursements from long-term care insurance. However, the reimbursements are inputs to produce long-term care services, which are different from outputs; that is, benefits accrued to the consumers of long-term services. In the SNA, the output of long-term care is measured in the general framework of double deflation, which measures real outputs by deflating nominal sales by output deflator and subtracting nominal costs deflated by input deflator. This methodology is valid only when suitable deflators that reflect consumers' welfare are available, however. In long-term care services, prices are regulated through the public insurance and are generally not representative of consumers' true preferences.

Recently, direct measures of output of non-market service sectors are being actively studied and advocated. The Atkinson Review (2005) recommends measuring output directly by counting the number of units for whom services are provided instead of measuring output by aggregating costs of producing the services. In addition, the Atkinson Review (2005) encourages that output is adjusted for the change in quality of services. Eurostat (2001) also recommends direct measurement and quality adjustment. In the United Kingdom, the Office for National Statistics calculates and publishes direct and quality-adjusted output indexes for public sector activities. (Office for National Statistics, 2007, 2008, 2015.) In the United States, pioneering research has been conducted during the 1990s, particularly at the National Bureau of Economic Research, measuring the quality of health care and adjusting for quality change in the calculation of deflators (Cutler and Berndt, eds. 2001). The Bureau of Economic Analysis is now developing a Health Care Satellite Account based on treatments of diseases (Dun, et al., 2015).

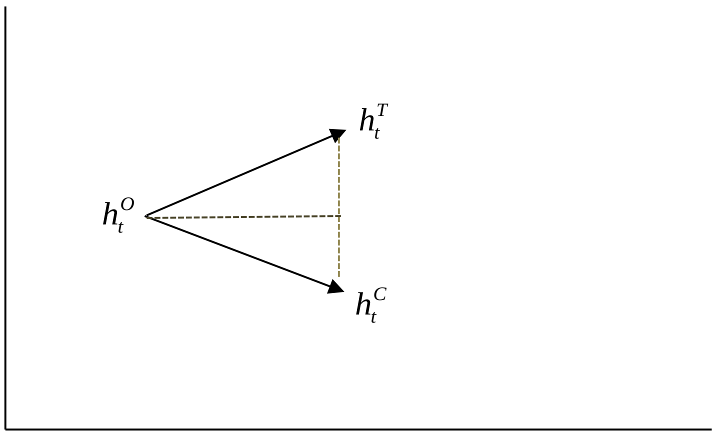
In this paper, we exemplify the direct method of measuring the output of long-term care services. This method directly measures output by aggregating the volume of services each unit of measurement consumes and, additionally, by assigning value of the services to each unit. We follow Dawson, et al. (2005), Castelli, et al. (2007) and Castelli, et al. (2008) in the construction of a quality-adjusted output index. Output consists of three components: unit of measurement, quality of care, and valuation of the quality. Schematically, we can write:

Output = Unit of measurement × Quality of care × Valuation

Output index should include not only the number of patients but also the improvement of status of the elderly attributable to long-term care. This is what a quality-adjusted output index is intended to do. The unit of measurement is the elderly who are covered by the long-term care insurance. All the elderly are enrolled in the insurance and are potentially eligible for long-term care services while a little more than 10 percent of the elderly actually receive such services. Quality of care is the improvement of status of the elderly caused by long-term care services. Valuation is the value of long-term care provided by long-term care insurance, which will be measured by the Quality of Life of each elderly.

The concept of the quality of long-term care can be explained as follows（Figure 1）.

Figure 1 The Concept of the Quality of Long-term Care



This exposition is inspired by the discussion in Jacobs, et al. (2006). Let the original status of an elderly at time t be h_t^O=0.5. Suppose that when she undergoes a treatment (provision of long-term care), her status will be h_t^T=0.7 with the apparent improvement in her status of $h_t^T - h_t^O$=0.2. (No time lag is assumed between the intervention and its results.) However, this is not the true improvement caused by long-term care. Suppose that when she does not undergo a treatment, her status will deteriorate to h_t^C=0.4. The true quality of care is $h_t^T - h_t^C$=0.3 while we can observe only $h_t^T - h_t^O$=0.2 because we usually do not know the natural history, h_t^C.

Now suppose that in the next year we have the original status, h_{t+1}^O=0.5, the status with a treatment, h_{t+1}^T=0.8, and the status without treatment, h_{t+1}^C=0.4. (Again, no time lag is assumed.) Namely, the original health status and the natural history are the same as time *t*. Then, the quality of health care at time *t*+1 is $h_{t+1}^T - h_{t+1}^C$=0.4 while we observe only $h_{t+1}^T - h_{t+1}^O$ =0.3. However, since $h_{t+1}^O = h_t^O$ and $h_{t+1}^C = h_t^C$, we can calculate the change in the true quality of health care as $(h_{t+1}^T - h_{t+1}^O) - (h_t^T - h_t^O) = h_{t+1}^T - h_t^T$.

It is not necessarily the case that the original statuses, h_t^O and h_{t+1}^O, are equal. Hence, we have to adjust the original statuses to compare outcomes, h_t^T and h_{t+1}^T. Risk adjustment just does this. Somewhat formally, we can model the health status of the treated patient as a function of the original status: $h_t^T = f_t(h_t^O)$ and $h_{t+1}^T = f_{t+1}(h_{t+1}^O)$. Adjusted health statuses with a common original status, $\bar{h}^O$, are $\bar{h}_t^T = f_t(\bar{h}^O)$ and $\bar{h}_{t+1}^T = f_{t+1}(\bar{h}^O)$. Then, the difference between these two outcomes is the change in quality of health care.

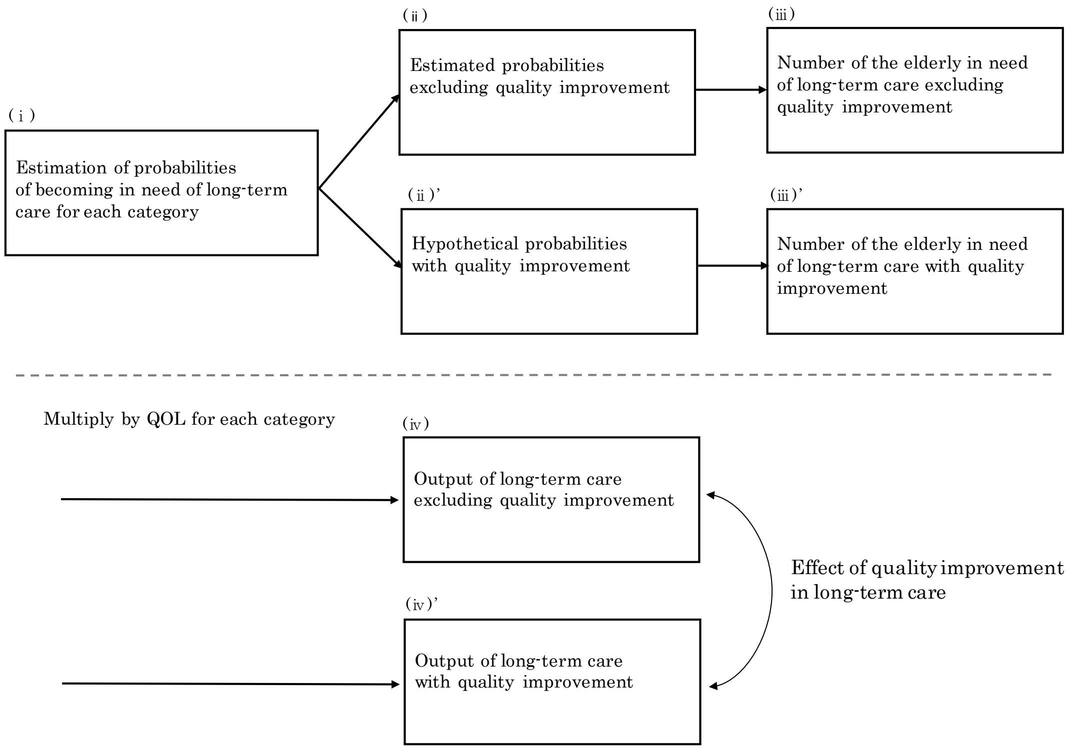
Now, we explain the calculation procedure. Quality-adjusted measure of long-term care is calculated by multiplying the number of the elderly by the quality of long-term care with further adjustment made to account for the valuation of the quality. The quality of long-term care is defined to be the improvement of the status of the elderly when they utilize long-term care compared with the status of the elderly when they do not utilize long-term care. The quality of long-term care services is the Quality of Life attached to each care level category.

We take as the unit of measurement the number of the elderly at each category of care level. Care level is assigned to each elderly according to the amount of the care needed and can be regarded as an indicator of the state of the elderly. (The categories of care level will be explained below together with institutional arrangements of the long-term care insurance system.) The quality of care is the category of care level to which each elderly is certified. We then attach a valuation to each care level by estimating quality of life (QOL) of each category. In sum, quality-adjusted output index is calculated as the number of the elderly at each category of care level multiplied by QOL of each category.

In this calculation, we have to adjust for the change in the risks that influence the state of the elderly. For example, as a person ages, she tends to require heavier long-term care. Therefore, we adjust for changes in risks by statistically estimating an equation that describes the relationship between risk factors such as age and comorbidities and the care level. The estimation will be explained below.

The calculation is summarized in Figure 2. We start with (i) the estimation of an equation that describes the determination of probabilities of becoming in need of long-term care for each care level. The estimated equation will be used to adjust for risk factors, which vary from time to time, and to enable the comparison of the output overtime.

Figure 2 The calculation procedure



After adjustment for risk factors we obtain (ii) estimated probabilities of becoming in need of care that excludes improvement of the quality of long-term care by excluding the effect of time dummies in the estimated equation. The time dummy in the equation represents effects specific to each year and common to all elderly people. These effects can be regarded as technological progress, in other words, as the quality of long-term care services. Hence, by suppressing the effects of time dummies we can calculate a hypothetical probabilities of becoming frail when no quality improvement is achieved.

Multiplying these probabilities by the number of the elderly gives (iii) the number of the elderly in each category of care level. Finally, we obtain (iv) output of long-term care without adjusting for quality improvement by multiplying (iii)above by QOL for each category.

Next, we go on to adjust for the quality of care by including the effects of time dummies in the estimated equation. We start with (i) the estimation of the equation that determines the probabilities of frailty. Then, we go to (ii)' instead of (ii) in Figure 2.In (ii)' we include the effects of time dummies on the state of the elderly in addition to the effects of risk factors. Then, (iii)' the number of the elderly in each category of care level is obtained just as the case of (iii). Finally, multiplying by QOL for each category gives (iv)' output of long-term care for which quality of care is adjusted.

2. Institutional Description

The Japanese long-term care insurance system covers, primarily, elderly people aged above 65 years old. People between 40 and 64 years old also enroll in the insurance. To obtain benefits, a policyholder needs to be certified as Requiring Support or Requiring Long-term Care by the insurer (municipality). Requiring Support is a classification for persons whose basic activities of daily living can be performed basically independently, but for whom some support is needed for procedural activities of daily living to prevent becoming in need of long-term care. Requiring Long-term Care is for persons whose basic activities of daily living cannot be performed independently and long-term care is needed.

The certification is made for Requiring support 1 to 2 and Requiring long-term care 1 to 5. (See Appendix) These categories are defined in terms of the time needed to take care of the elderly, not in terms of the severity of the condition of the elderly. However, a positive correlation is observed between support/care levels and frail conditions of the elderly (Tajika and Kikuchi, 2003). The Requiring Support 1 is the least-frail elderly for whom, in typical cases, basic activities of daily living such as walking can be performed independently but some support is needed concerning standing up, getting up, standing on one foot. The Requiring Long-term Care 5 is the most frail who, in typical cases, capabilities of movement have deteriorated so severely that daily living is almost impossible without long-term care. Tajika and Kikuchi(2003) points out that the Requiring Long-term Care 3 is the threshold between mild and severe conditions. They classify the elderly with less than and equal to Requiring Long-term Care 2 as mild.

The services provided to the elderly certified as Requiring Support are called "preventive benefits" while those provided to the elderly certified as Requiring Long-term Care are called "long-term care benefits." However, those services are not much different across these categories. Therefore, we will not distinguish between "preventive" and "long-term care" benefits.

The Japanese long-term care insurance system provides benefits for two types of care. One is home care, the other facility care. Home care includes home-visit care, day care, short-term admission to facilities, and rental welfare equipment.

3. Data and Descriptive Statistics

The Tokyo Metropolitan Institute of Gerontology launched a longitudinal study of aging and health in 2002 at Kusatsu in Japan. All residents aged 65 years or older[5] have been invited to participate in baseline and follow-up surveys and medical examinations. The medical examination is called the Nikkori (Smile) examination and is held at a local public health center once a year. The survey is called the Iki-iki (Lively) survey and is conducted every two years. These surveys and examinations contain detailed physical and medical information including diseases that the elderly had suffered or is suffering. In particular, they include information on pre-existing stroke and hypertension, which we will use as explanatory variables in the estimation. Actually, Levine, et al. (2014) documents that myocardial infarction and stroke hospitalizations are associated with significant increases in functional disability. All participants provided written informed consent under conditions approved by the Ethics Committee at the Tokyo Metropolitan

[5] Up to 2005, 70 years or older.

Institute of Gerontology.

The physical and medical information is linked to the information on the long-term care benefits approved by the long-term care insurance system. The latter information also includes the support or care level if the elderly is certified as Requiring Support or Long-term Care.

Since the Nikkori (Smile) medical examination and the Iki-iki (Lively) health survey are conducted annually and biannually, respectively, their annual data are transformed into quarterly data. In the estimation below, pre-existing diseases of stroke and hypertension are used. If an elderly is found to suffer from a stroke in a year, she is judged to have a pre-existing stroke after the beginning of that year and not before that.

Sample is restricted to those who are older than 70 years old because, as explained above, the threshold of the eligibility for reimbursements in the insurance system is 70 years old up to 2005 and 65 after 2006. To secure consistency of the sample, we put aside data of those whose ages are less than 70. Missing data of age and history of a disease (stroke) are imputed using the data, if they exist, before or after the missing data. Specifically, a missing data of history of stroke is imputed as one if data in previous years indicate that the person has history of stroke. Data from 2003 to 2009 are used in the analysis below. The number of individuals is 1,482 and the number of total observations is 6,527.

Table 1 shows basic statistics of the sample used for the estimation; from 2002 to 2009. The average age is 77.1 years old. As for the preexisting conditions, 15 percent of the elderly has suffered from stroke, currently or in the past.

To get a feel about the overall degree of frailty of the elderly, we assign a point to each condition; one to Independent, two to Requiring Support 1, three to Requiring Support 2, four to Requiring Long-term Care 1, and so on. When averaged over all elderly population, the mean of the frailty points is 1.26.

The share of the elderly in each frailty condition is 89.9 percent for the elderly who do not need support or care (Independent). As for Requiring Support/Care conditions, we aggregate categories in accordance with Tajika and Kikuchi (2003): aggregate categories from Requiring Support 1 to Requiring Long-term Care 2 into “Mild” while aggregating categories above Requiring Long-term Care 3 into "Severe." The share is 7.9 percent for the mild care level and 2.2 percent for the severe care level. Below these figures, the ratio for each category is shown.

Table 1 Descriptive Statistics

	2002-2009			2002		2003		2004		2005	
	Obs	Mean	Std. Dev.	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
Age	6,527	77.10	5.67	1,001	76.94	1,072	77.32	996	77.15	1,088	77.23
Stroke(0:No 1:Yes)	6,527	0.15	0.36	1,001	0.07	1,072	0.11	996	0.11	1,088	0.13
Sex(1:male 2:female)	6,527	1.58	0.49	1,001	1.60	1,072	1.60	996	1.59	1,088	1.58
Care level(current)	6,527	1.26	0.90	1,001	1.22	1,072	1.29	996	1.25	1,088	1.31
		(share)			*(share)*		*(share)*		*(share)*		*(share)*
Independent	*5,869*	*89.9%*		*909*	*90.8%*	*947*	*88.3%*	*889*	*89.3%*	*960*	*88.2%*
Mild(～Requiring long-term care 2)	*513*	*7.9%*		*77*	*7.7%*	*100*	*9.3%*	*89*	*8.9%*	*95*	*8.7%*
Severe(Requiring long-term care 3～)	*145*	*2.2%*		*15*	*1.5%*	*25*	*2.3%*	*18*	*1.8%*	*33*	*3.0%*
Requiring support 1	*133*	*2.0%*		*24*	*2.4%*	*29*	*2.7%*	*25*	*2.5%*	*21*	*1.9%*
Requiring support 2 □Requiring long-term care 1	*267*	*4.1%*		*34*	*3.4%*	*46*	*4.3%*	*49*	*4.9%*	*59*	*5.4%*
Requiring long-term care 2	*113*	*1.7%*		*19*	*1.9%*	*25*	*2.3%*	*15*	*1.5%*	*15*	*1.4%*
Requiring long-term care 3	*59*	*0.9%*		*11*	*1.1%*	*13*	*1.2%*	*10*	*1.0%*	*15*	*1.4%*
Requiring long-term care 4	*51*	*0.8%*		*1*	*0.1%*	*5*	*0.5%*	*5*	*0.5%*	*14*	*1.3%*
Requiring long-term care 5	*35*	*0.5%*		*3*	*0.3%*	*7*	*0.7%*	*3*	*0.3%*	*4*	*0.4%*

	2006		2007		2008		2009	
	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
Age	626	76.79	629	76.88	607	76.96	508	77.39
Stroke(0:No 1:Yes)	626	0.22	629	0.21	607	0.22	508	0.26
Sex(1:male 2:female)	626	1.57	629	1.56	607	1.56	508	1.54
Care level(current)	626	1.22	629	1.23	607	1.26	508	1.28
		(share)		*(share)*		*(share)*		*(share)*
Independent	*576*	*92.0%*	*578*	*91.9%*	*550*	*90.6%*	*460*	*90.6%*
Mild(～Requiring long-term care 2)	*36*	*5.8%*	*38*	*6.0%*	*44*	*7.2%*	*34*	*6.7%*
Severe(Requiring long-term care 3～)	*14*	*2.2%*	*13*	*2.1%*	*13*	*2.1%*	*14*	*2.8%*
Requiring support 1	*13*	*1.3%*	*6*	*0.6%*	*8*	*0.8%*	*7*	*0.6%*
Requiring support 2 □Requiring long-term care 1	*16*	*1.6%*	*22*	*2.1%*	*23*	*2.3%*	*18*	*1.7%*
Requiring long-term care 2	*7*	*0.7%*	*10*	*0.9%*	*13*	*1.3%*	*9*	*0.8%*
Requiring long-term care 3	*3*	*0.3%*	*2*	*0.2%*	*2*	*0.2%*	*3*	*0.3%*
Requiring long-term care 4	*6*	*0.6%*	*7*	*0.7%*	*7*	*0.7%*	*6*	*0.6%*
Requiring long-term care 5	*5*	*0.5%*	*4*	*0.4%*	*4*	*0.4%*	*5*	*0.5%*

Table 1 also provides a long-term trends of age and pre-existing diseases. The average age followed an increasing trend from 76.9 years in 2002 to 77.2 years in 2005 before a sharp decline in 2006 to 76.8 years. From 2006 to 2009 a clear upward trend is observed (77.4 years in 2009).The share of the elderly who suffer from stroke continuously rose from 7 per cent in 2002 to 26 per cent in 2009 with a large jump in 2006.

The mean of the frailty points rose from 1.22 in 2002 to 1.31 in 2005. After a fall in 2006 to 1.22, it steadily rose to 1.28 in 2009. The share of the Independent category declined from 90.8 per cent in 2002 to 88.2 per cent in 2005. After a sudden jump to 92.0 per cent in 2006, it declined to 90.6 per cent in 2009. The share of the "Mild" category showed no clear trend from 2002 to 2005. After a large drop in 2006 to 5.8 per cent, it rose to 6.7 per cent in 2009. The share of the "Severe" category continuously rose from 1.5 per cent in 2002 to 3.0 per cent in 2005. After a large drop in 2006 to 2.2 per cent, it rose to 2.8 per cent in 2009.

Table 2 is a matrix that shows the transition probabilities from the care level of one year earlier to the current care level, including death. For example, 97 percent of the independent elderly remain independent after a year, 0.7 percent of them will become Requiring Support 1, 1.1 percent Requiring Support 2, and so on. The large percentage figures on the diagonal indicate that people tend to find themselves in the same categories as those in the previous year. Naturally, they often stay near the original categories even if they make transitions and it is infrequent that they jump into far away categories. These strongly indicate state dependence of frail conditions. In the "Mild" categories, the elderly tend to make transitions to more severe categories than to less severe ones. It is a little surprising that a moderate number of the elderly in the "Severe" categories still go back to less severe categories. People tend to die more often when they are in more severe categories.

Table 2 Transition Matrix

		Care level (current)								
		independent	Requiring Support 1	Requiring Support 2 / Requiring long-term care 1	Requiring long-term care 2	Requiring long-term care 3	Requiring long-term care 4	Requiring long-term care 5	death	Total
Care level (t-1)	independent	97.2%	0.7%	1.1%	0.4%	0.2%	0.1%	0.1%	0.2%	100.0%
	Requiring Support 1	0.0%	64.6%	31.9%	1.8%	0.9%	0.0%	0.0%	0.9%	100.0%
	Requiring Support 2 / Requiring long-term care 1	0.0%	6.1%	78.1%	11.2%	3.6%	0.0%	0.5%	0.5%	100.0%
	Requiring long-term care 2	0.0%	1.2%	12.9%	63.5%	11.8%	5.9%	1.2%	3.5%	100.0%
	Requiring long-term care 3	0.0%	0.0%	0.0%	17.0%	59.6%	19.1%	2.1%	2.1%	100.0%
	Requiring long-term care 4	0.0%	0.0%	0.0%	3.0%	0.0%	81.8%	12.1%	3.0%	100.0%
	Requiring long-term care 5	0.0%	0.0%	0.0%	0.0%	0.0%	14.8%	85.2%	0.0%	100.0%
Total		89.7%	2.0%	4.1%	1.7%	0.9%	0.8%	0.5%	0.3%	100.0%

4. The Model and Estimation

In this section, we estimate a multinomial mode that determines the care level of each elderly people. This is the first step (i) in Figure 2.

The dependent variable is the indicator variable that shows the level of need for support or care. On top of the independent state, where there is need for neither support nor care, there are two categories of Requiring Support and five categories of Requiring

Long-term Care so that $y_{it} = \{1,\ 2, \ldots ,7\}$, with 1 indicating the independent state and 7 Requiring Long-term Care 5. To model this categorical variable, an ordered logit model is employed because there is a natural order in it.

The latent variable model is

$$y_t^* = z_{it}\gamma + \rho y_{t-1} + \lambda_t + u_{it},$$

where z_{it} is the vector of explanatory variables, y_{t-1} is the care level in the previous year, λ_t is a dummy variable indicating each year, t, and u_{it} is an error term.

Cut points for respective categories are

$$\alpha_1 < \alpha_2 < \cdots < \alpha_J.$$

The actual outcome, y, realizes according as the latent variable, y^*, is located below, between or above the cut points:

$$\begin{aligned} \mathrm{y} = 1 &\quad \text{if } y^* \le \alpha_1 \\ \mathrm{y} = 2 &\quad \text{if } \alpha_1 < y^* \le \alpha_2 \\ \mathrm{y} = 3 &\quad \text{if } \alpha_2 < y^* \le \alpha_3 \\ &\quad \vdots \\ \mathrm{y} = 7 &\quad \text{if } y^* > \alpha_J \end{aligned}$$

Probability distributions are specified as logit distribution, $\Lambda(.)$.

$$\mathrm{P}(y_{it} = 1|z_{it} + \rho y_{t-1} + \lambda_t) = \Lambda([\alpha_1 - (z_{it}\gamma + \rho y_{t-1} + \lambda_t)]$$
$$\mathrm{P}(y_{it} = 2|\cdot) = \Lambda[\alpha_2 - (z_{it}\gamma + \rho y_{t-1} + \lambda_t)] - \Lambda([\alpha_1 - (z_{it}\gamma + \rho y_{t-1} + \lambda_t)]$$
$$\vdots$$
$$\mathrm{P}(y_{it} = J|z_{it} + \rho y_{t-1} + \lambda_t) = 1 - \Lambda([\alpha_J - (z_{it}\gamma + \rho y_{t-1} + \lambda_t)]$$

The time dummy, λ_t, represents effects specific to each year and common to all elderly people. This variable can be regarded as representing technological progress in caring of the elderly because a lower value of λ_t translates into lower probability of becoming worse long-term care status holding attributes of the elderly constant. This technological progress is the quality of long-term care services. The estimates of λ_t will play a central role in the calculation of the quality-adjusted output index of long-term care services.

Explanatory variables, z_{it}, include age, sex and preexisting stroke. As we mentioned previously, Levine, et al. (2014) documents that myocardial infarction and stroke hospitalizations are associated with significant increases in functional disability, and we can use hypertension as a surrogate indicator of MI.

The care level in the previous year, y_{t-1}, is included in the regression to account for a phenomenon called state-dependence. As is explained in Sugihara, et al. (2017), this year's care level depends on previous year's care level: when one year's care level becomes severe, next year's care level tends to remain severe.

Prior distributions for the coefficients, γ and ρ, and time dummies, λ_t, are assumed to be normal distributions with mean zero and variance 1000: take a generic coefficient μ, then, $\mu \sim N(0,1000)$. The choice of the variance of 1000 is intended to represent a diffuse prior. Gelman and Hill (2007) give a thoughtful discussion on the appropriateness of this value in the context of the logistic models or log-transformed regressors. They argue that in logistic and logarithmic regressions, typical changes in outcomes are on the scale of 0.1 or 1, but not 10 or 100, so that one would not expect to see coefficients much higher than 10 in absolute values as long as the regressors are also on a reasonable scale. Although their choice of the value of variance is 100^2, we believe that their argument applies to our choice, 1000.

The model is estimated by the Markov chain Monte Carlo (MCMC) method utilizing the WinBUGS software. Convergence is checked by the Gelman-Rubin statistics. Burn-in is 2,000 and the number of iterations used in calculation is 10,000.

Table 3 shows estimation results. Among risk factors, age strongly increases the probability of becoming in need of long-term care while sex and history of stroke do not significantly influence the severity of state of the elderly. Care levels in the previous year has a strong influence on the care levels of this year, suggesting the existence of state-dependence explained in Sugihara, et al. (2017).

Time dummies are negative and their magnitude is increasing over time, implying that quality of long-term care is steadily improving. This information will be used when we calculate how much improvement of the quality of care contributes to long-term care output.

Table 3 Single Equation (for estimate the output)

node	mean	sd	2.5%	median	97.5%
Lagged care level	0.85	0.12	0.62	0.85	1.08
Age	2.21	0.22	1.89	2.19	2.78
Sex	0.10	2.70	−6.35	0.58	4.09
Stroke	1.10	0.81	−0.40	1.09	2.79
Time dummy					
2002	−38.69	2.03	−41.83	−38.87	−33.88
2003	−39.92	1.96	−43.04	−40.10	−35.55
2004	−41.35	1.92	−44.51	−41.52	−37.45
2005	−42.59	1.91	−45.79	−42.75	−38.92
2006	−44.95	1.92	−48.25	−45.09	−41.37
2007	−46.01	1.96	−49.44	−46.11	−42.33
2008	−46.92	2.02	−50.48	−46.99	−43.01
2009	−48.87	2.10	−52.68	−48.91	−44.76

These estimates enable us to calculate risk-adjusted probabilities of becoming frail by substituting the mean values for each year into each explanatory variable in the estimated equation.

We calculate hypothetical probabilities of needing long-term care by suppressing the effects of time dummies, λ, in the estimates of the multinomial model. This is done by setting the coefficients, ρ, on time dummies equal to zero in the calculation of the estimated probabilities of needing long-term care. The resulting probabilities represent hypothetical probabilities obtained if we assume that no improvement in the quality of long-term care services occurred.

Table 4 shows the results. Once the risks are adjusted, the probabilities of frailty become smaller for severe categories of frailty.

Table4 Probability of each care level status: Without quality improvement

		Care level							Total
		independent	Requiring Support 1	Requiring Support 2 /Requiring long-term care 1	Requiring long-term care 2	Requiring long-term care 3	Requiring long-term care 4	Requiring long-term care 5	
Year	2002	90.71%	2.65%	4.02%	1.29%	0.69%	0.32%	0.32%	100.0%
	2003	86.33%	2.71%	5.47%	2.31%	1.32%	1.28%	0.59%	100.0%
	2004	85.99%	1.95%	5.73%	2.86%	1.43%	1.33%	0.71%	100.0%
	2005	85.79%	0.79%	4.03%	3.12%	2.41%	2.11%	1.76%	100.0%
	2006	87.31%	0.26%	3.14%	2.74%	2.11%	2.13%	2.32%	100.0%
	2007	88.56%	0.03%	1.02%	2.63%	2.17%	2.60%	2.99%	100.0%
	2008	89.79%	0.00%	0.14%	0.94%	1.86%	3.00%	4.27%	100.0%
	2009	90.55%	0.00%	0.01%	0.11%	0.52%	2.19%	6.63%	100.0%

We can also calculate probabilities including quality improvements in long-term care services by incorporating the effects of time dummies in the estimated equation. The results will be presented below.

6. Calculation of a Quality-Adjusted Output of Long-term Care

In this section, a quality-adjusted output index using the estimation results of the previous section. We have calculated probabilities of becoming needy of long-term care for each care level in the previous section. Now, we translate the estimated probabilities into the number of elderly people in each care level category by multiplying the total number of elderly in the population by estimated probabilities for each category of care level.[6] This is the step (iii) in Figure 2.

In the final step (iv), we further multiply the number of the elderly in each category by the quality of life for each category. The quality of life for each category is calculated following the method of Dolan (1997). He modeled valuations for EuroQol health states to convert EuroQol health states into quality of life. Our data contains similar questions on health status of three of five areas of the EuroQol questionnaire. We use this information and the methodology of Dolan (1997) to obtain the quality of life of each category of care levels.

EuroQol consists of five areas: Mobility, Self-care, Usual activities, Pain/discomfort, and Anxiety/depression. Each area is comprised of three levels with the first level no problem and the third incompetence. (Appendix Table A1)

Dolan (1997) modeled valuations for EuroQol health states to obtain a single index of health-related quality of life. He estimated parameters that represent values for each health state in EuroQol. (Appendix Table A2)

We start from the state of full health of QOL one. If a person has any problem in mobility, self-care or usual activity, a constant 0.081 is subtracted from 1 resulting in 0.919. Next, if mobility is level 2, MO=1times0.069 is subtracted from 0.919 resulting in0.85. Further, if self-care is level 2, SC=2 times 0.104is subtracted from 0.85 resulting

[6] These numbers might be regarded as output index without quality adjustment if numbers in each category are aggregated (possibly weighted by cost shares).

in 0.642 and so on.

Since we excluded pain/discomfort and anxiety/depression from the calculation of QOL, the estimated QOL is upward biased. However, this is inconsequential when we want to know the change in the quality of long-term care.

Table 5 shows the estimated QOL for each category of care level. Up to Requiring Long-term Care 1, QOL is relatively high. QOL for Requiring Long-term Care 2 and 3 exhibits recognizable decline and decline for Requiring Long-term Care 4 and 5 is substantial.

Table5 The QOL for each category of care level

	QOL (average)
independent	0.997
Requiring Support 1	0.976
Requiring long-term care 1	0.902
Requiring long-term care 2	0.785
Requiring long-term care 3	0.623
Requiring long-term care 4	0.340
Requiring long-term care 5	0.067

To obtain the quality-adjusted output of long-term care, we further multiply the number of the elderly in each category by the quality of life for each category. Resulting numbers are shown in Table 6. The right-most column of Table 6 shows the resultant quality-adjusted output index, which will be displayed in Figure 3 below along with the output index with quality improvements calculated below.

Table6 Output index: Without quality improvement

year	independent	Requiring Support 1	Requiring Support 2 /Requiring long-term care 1	Requiring long-term care 2	Requiring long-term care 3	Requiring long-term care 4	Requiring long-term care 5	Total of QOL	Output index (excluding year dummy)
2002	1,151.5	32.9	46.2	12.9	5.5	1.4	0.3	1,250.6	1.000
2003	1,125.9	34.6	64.5	23.7	10.7	5.7	0.5	1,265.6	1.012
2004	1,152.4	25.6	69.4	30.2	12.0	6.1	0.6	1,296.3	1.037
2005	1,181.2	10.6	50.2	33.8	20.7	9.9	1.6	1,308.1	1.046
2006	1,243.1	3.6	40.5	30.7	18.8	10.4	2.2	1,349.1	1.079
2007	1,303.9	0.5	13.6	30.5	19.9	13.0	3.0	1,384.5	1.107
2008	1,367.0	0.0	1.9	11.3	17.7	15.6	4.4	1,417.9	1.134
2009	1,425.7	0.0	0.2	1.3	5.1	11.7	7.0	1,451.0	1.160

We repeat the same procedure, but this time incorporating the contribution from the quality improvement. Table 7 shows the results.

Table7 Probability of each care level status: With quality improvement

		Care level							Total
		independent	Requiring Support 1	Requiring Support 2 /Requiring long-term care 1	Requiring long-term care 2	Requiring long-term care 3	Requiring long-term care 4	Requiring long-term care 5	
Year	2002	90.71%	2.65%	4.02%	1.29%	0.69%	0.32%	0.32%	100.0%
	2003	88.59%	2.58%	4.64%	1.82%	1.12%	0.85%	0.41%	100.0%
	2004	89.86%	2.38%	4.48%	1.55%	0.86%	0.59%	0.28%	100.0%
	2005	89.14%	1.84%	4.52%	1.98%	1.04%	1.05%	0.44%	100.0%
	2006	92.13%	1.56%	3.20%	1.10%	0.53%	0.91%	0.55%	100.0%
	2007	92.04%	1.60%	3.06%	1.27%	0.64%	0.68%	0.70%	100.0%
	2008	91.45%	1.36%	3.28%	1.65%	0.78%	0.62%	0.87%	100.0%
	2009	91.46%	0.91%	3.12%	1.80%	0.97%	0.84%	0.89%	100.0%

Now, we translate the hypothetical probabilities without quality change into the number of elderly people in each care level category by multiplying the total number of elderly by estimated and hypothetical probabilities.

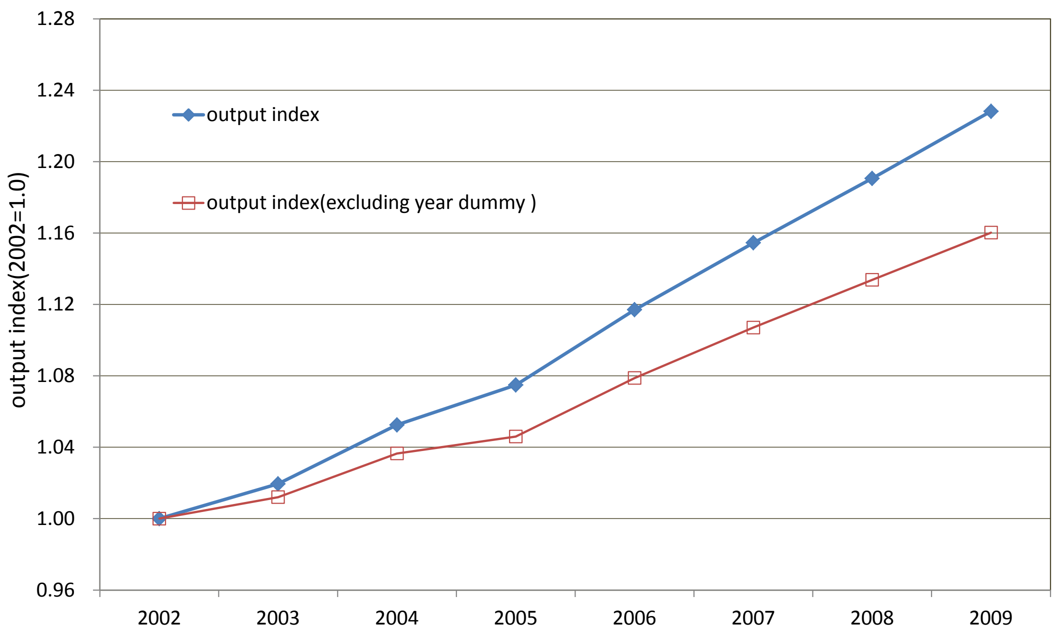
We further multiply the number of the elderly in each category by the quality of life for each category. Resulting numbers are hypothetical outputs of long-term care with quality improvements. Table 8 shows the results.

Table8 Output index: With quality improvement

year	independent	Requiring Support 1	Requiring Support 2 /Requiring long-term care 1	Requiring long-term care 2	Requiring long-term care 3	Requiring long-term care 4	Requiring long-term care 5	Total of QOL	Output index
2002	1,151.5	32.9	46.2	12.9	5.5	1.4	0.3	1,250.6	1.000
2003	1,155.5	32.9	54.7	18.7	9.1	3.8	0.4	1,275.0	1.020
2004	1,204.1	31.2	54.3	16.3	7.2	2.7	0.3	1,316.2	1.052
2005	1,227.3	24.8	56.3	21.4	9.0	4.9	0.4	1,344.1	1.075
2006	1,311.8	21.8	41.3	12.4	4.7	4.4	0.5	1,396.9	1.117
2007	1,355.2	23.1	40.8	14.8	5.9	3.4	0.7	1,443.8	1.155
2008	1,392.3	20.2	45.1	19.7	7.4	3.2	0.9	1,488.9	1.191
2009	1,440.0	14.1	44.4	22.4	9.5	4.5	0.9	1,535.9	1.228

Figure 3 exhibits the estimated output indexes with and without quality adjustment. Both indexes starts at 1 in 2002 as a result of normalization. The output index without quality improvement increased to 1.16 in 2009, while the index with quality improvement increased to 1.228 in 2009. The difference is the contribution of quality improvement, which is substantial.

Figure 3 Output index



The output of long-term care services increased steadily even before the adjustment of the quality of care. After the quality adjustment, the output index increased more rapidly. The overall conclusion is that the direct method of output measurement is a promising way for non-market service sectors and quality adjustment is potentially very important.

7. Conclusion

The long-term care service sector is growing rapidly in Japan. However, the measurement of its output is problematic since traditional measures adopt cost-based approaches or double-deflation method with dubious deflators. This paper exemplified the direct method of measuring the output of long-term care services, which directly measures output by aggregating the volume of services each unit of measurement consumes and, additionally, by assigning value of the services to each unit.

We started with (i) the estimation of an equation to adjust for risk factors. By suppressing the effect of time dummies in the estimated equation, we obtained (ii) estimated probabilities of becoming in need of care when the quality of care is held constant. Multiplying these probabilities by the number of the elderly gave (iii) the number of the elderly in each category of care level. Finally, we obtained (iv) output of long-term care without adjusting for quality improvement by multiplying (iii) above by QOL for each category.

Next, we went on to adjust for the quality of care by including the effects of time dummies in the estimated equation. We proceeded in parallel with the above steps to obtain the quality-adjusted output index.

The output of long-term care services increased steadily even before the adjustment of the quality of care. After the quality adjustment, the output index increased more rapidly. Overall conclusion is that the direct method of output measurement is a promising way for non-market service sectors and quality adjustment is potentially very important.

Appendix: General Description of the Conditions of the Elderly Who Require Support/Long-term Care

First, the elderly are classified into three broad categories, Independent, Requiring Support and Requiring Long-term Care. Then, Requiring Support is divided into two subcategories and Requiring Long-term Care into five.

1. Independent (Requiring neither support nor care)
Basic activities of daily living such as walking and standing up can be performed independently and procedural activities of daily living such as taking medicine and making a phone call can be done.

2. Requiring Support
Basic activities of daily living can be performed basically independently but some support is needed for procedural activities of daily living to prevent becoming in need of long-term care.

2-1. Requiring Support 1
Basic activities of daily living can be performed basically independently but some support is needed concerning standing up, getting up, and standing on one foot.

2-2. Requiring Support 2
Compared with the Requiring Support 1, the ability to perform basic activities of daily living such as walking, body washing, keeping track of finances and clipping nails has deteriorated but possibly improved.

3. Requiring Long-term Care
Basic activities of daily living cannot be performed independently and long-term care is needed.

3-1. Requiring Long-Term Care 1
The same as Requiring Support 2 but their conditions will remain.

3-2. Requiring Long-Term Care 2

In addition to the condition of the Requiring Long-Term Care 1, care of basic activities of daily living is partially needed concerning wear/pull off trousers, moving and daily decision making.

3-3. Requiring Long-Term Care 3

Compared with the Requiring Long-Term Care 2, the ability to perform both basic and procedural activities of daily living has deteriorated significantly concerning washing face, grooming one's hair, oral care, urination/defecation and transferring from one place to another and overall long-term care is needed.

3-4. Requiring Long-Term Care 4

In addition to the condition of the Requiring Long-Term Care 3, capabilities of movement have deteriorated and dietary intake and communication become difficult so that daily living is difficult without long-term care.

3-5. Requiring Long-Term Care 5

Capabilities of movement have deteriorated further from the Requiring Long-Term Care 4 and swallowing and memorization/understanding become difficult so that daily living is almost impossible without long-term care.

Appendix Table A1

Area	Level	Description
Mobility	1	No problems walking about
	2	Some problems walking about
	3	Confined to bed
Self-care	1	No problems with self-care
	2	Some problems washing or dressing self
	3	Unable to wash or dress self
Usual activity	1	No problem with performing usual activities (eg. Work, study, housework, family or leisure activities)
	2	Some problems with performing usual activities
	3	Unable to perform usual activities

Appendix Table A2

Variable	Value of variable		Estimated coefficient
a	Constant	any move away from full health	0.081
MO	1	If mobility is level 2	0.069
	2	If mobility is level 3	
	0	Otherwise	
SC	1	If self-care is level 2	0.104
	2	If self-care is level 3	
	0	Otherwise	
UA	1	If usual activity is level 2	0.036
	2	If usual activity is level 3	
	0	Otherwise	
M2	1	If mobility is level 3	0.176
	0	Otherwise	
S2	1	If self-care is level 3	0.006
	0	Otherwise	
U2	1	If self-care is level 3	0.022
	0	Otherwise	

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