

# The Dynamic Analyses of the Regional Differences in Japanese Public Long-Term Care Insurance System

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## Abstract

We analyzed the dynamic properties of regional differences in Japanese public long-term care insurance system. The standing order (high and low) of each region's user rate, defined as the ratio of service users to insured individuals, is not very mobile. By using Markov transition matrixes, we calculated the standing order mobility index, and found that the degree of mobility is greater in the first half (2000-2005) than the second half (2006-2012) for the group of regions with higher user rates. Hence, the 2005 reform, which aimed to remedy the regional differences, did not seem to alleviate the standing order inertia.

Keywords: long-term care, regional difference, Markov transition matrix

## 1. Introduction

The objective of this research is to analyze the dynamic properties of regional differences in the public long-term care insurance system. The system started in April 2000 to replace public old age welfare system with public insurance system. Since then, along with the aging Japanese demographic structure, the number of insured individuals, the number of care service users, and the cost have been increasing rapidly. The care service users pay 10% user fee. The remaining service cost is financed by insurance premium paid by covered individuals (50%) and by local and national public fund (50%). There are wide differences in regional figures with respect to the long-term care insurance system because it is managed by municipalities as insurers. The system is reviewed at every 5 years for major reform. The first major reform took place in 2005. At the time, Japanese government recognized the rapid increase in cost and the wide differences in regional figures. In fact, The Ministry of Health, Labor, and Welfare (henceforth MHLW) stated in the 2005 report that biased regional distribution of service facilities and lax discipline on municipal management (especially on the review process of requests for certification) need to be corrected because these are the causes that will boost the national cost of long-term care services through widening regional differences. So the government took several measures to put brakes on the increasing cost and to remedy the regional differences to ease the pressure on local and national fiscal management. In Japan, it is expected that the public expenses that are related to services to elderly people such as pension, medical services, and long-term care services, will increase rapidly because of the aging demographic structure. The trend will add a further pressure on the fiscal management of Japanese government whose fiscal condition is already devastated through the long recession years in the 1990s and 2000s. Therefore, it is important to predict the future trend of the regional differences in public long-term care insurance system to measure the fiscal impact on those who have concerns in the system.

In this research, we analyzed the dynamic properties of the regional differences in user rates defined as

the ratio of long-term care service users relative to insured individuals. The main findings are summarized as follows.

( i ) A simple theoretical model predicts that each region's user rate converges to a unique globally stable steady state. The convergence, however, could be conditional, i. e., each region's user rate may converge to a region-specific steady state which is determined by the region's parameters.

( ii ) We calculated the user rates of 47 Japanese regions (prefectures) for the fiscal years between 2000 and 2012. (Data source: The Japanese Ministry of Health, Labor, and Welfare.) Then, we divided the 47 regions into 5 groups according to the standing order (high and low) of user rates. It turned out that the user rate of a group with higher (lower) user rate grows slower (faster). Hence, the regional user rates seem to exhibit a tendency to converge. The convergence, however, may be conditional. It turned out as well that the standing order of regional user rates is not quite variable.

( iii ) By using average Markov transition matrixes for the first half (2000-2005) and for the second half (2006-2012), we calculated the index of standing order mobility so as to evaluate the effects of the 2005 reform which aimed to remedy the differences in regional figures of public long-term care insurance system. It turned out that the degree of mobility is greater in the first half than the second half for the group of regions with higher user rates. The 2005 reform, hence, did not seem to alleviate the standing order inertia.

( iv ) The small degree of variation in the standing order suggests the existence of region-specific factors. With the help of preceding researches, we chose 3 factors {the certification rate, the late-stage (75 years or older) old age ratio, and the ordinary balance rate} to account for the regional differences in user rates, and recalculated the mobility index by using the residuals. It turned out that the degree of mobility is improved for all the 5 groups and for both before and after the 2005 reform. Thus, the convergence might have been conditional. If region-specific factors were not removed, each region's user rate would converge to region-specific steady state, and the standing order of regional user rate would be invariant. It turned out as well that the 2005 reform hardly affected the standing order mobility of residual user rates. In addition, the analysis also revealed that the improvement in the standing order variation seems small even after the regional factors are removed. Therefore, there might be factors other than our choice that could explain the regional differences.

This paper is organized as follows. In section 2, we briefly review the structure of the public long-term care insurance system; The objective of the system, how an insured individual applies for care service provision, the statistical figures to grasp the trend and the current status of the system, preceding researches, and the implication of the 2005 reform. In the research, we look at the dynamic behavior of the “user rate” defined as the number of those who use the long-term care services relative to the primary-insured individuals (65 years or older). By using the MHLW data, we calculated long-term care service user rates of 47 regions (prefectures) from 2000 to 2012 fiscal years. We paid attention on the comparisons between the dynamic behavior before (2000-2005) and after (2006-2012) the 2005 reform. The data show the following properties. The national average user rate increased between 2000 and 2005 at a diminishing growth rate and ceased to grow. After 2006, it began to grow again, at a diminishing growth rate. The Gini coefficient of regional user rates decreased between 2000 and 2012. Although the coefficient of variation did not show clear trend, the ratio of maximum value to the minimum value also decreased. These

properties suggest that the regional user rates may be converging. The 2005 reform may have affected the regional user rates, but not quite the intended way. The MHLW suggested in 2005 report that the regional differences in the long-term care insurance system figures might be caused by structural region-specific reasons. Hence, even if the regional user rates converge, the standing order of regional user rates, from the highest to the lowest, will not be variable, i.e., the regions with high user rate will not exchange their positions with the regions with low user rate in the standing order. In addition, the observations suggest that the convergence in regional user rates may be conditional on region-specific characteristics, i.e., each region's user rate is converging to region-specific steady state. To investigate if the 2005 reform had any effect on the standing order of regional user rates, we divided 47 regions into 5 groups according to the value of each region's user rate, from the highest to the lowest, and looked at the dynamic properties of each group's user rate. It turned out that the user rate of the highest (lowest) group grows slower (faster). Therefore, the regional user rates may be converging. It is not clear, however, if they are converging to the same steady state. In addition, the standing order of each region's user rate is quite immobile, before and after the 2005 reform. These observations suggest that the convergence may be conditional on region-specific elements, and the 2005 reform did not seem to make the standing order more mobile. In section 3, we construct a simple theoretical model of the Japanese long-term care insurance system. Then the model is analyzed to derive dynamic properties of the system. It will be shown that each region's user rate converges to a unique and globally stable steady state. If regions have different parameter values, however, then each region converges to region-specific steady state (conditional convergence). Furthermore, it will be shown that the theoretical model can replicate the motion of regional user rates observed in actual statistical data. In section 4, we construct average Markov transition matrixes to analyze each region's mobility across the standing order of regional user rates. We also evaluate if the 2005 reform made the standing order more variable because it tried to remedy regional differences in user rates. It will be shown that the 2005 reform seems to have had little effect on improving the regional mobility. In fact, the regions with higher user rate became less mobile after 2005. The analysis in section 4 suggests that the regional mobility might be dependent on region-specific elements. Therefore, in section 5, we try to remove region-specific elements (the rate of care need certification by municipalities, the late-stage (75 years or older) old age population rate, and the regional ordinary balance rate) from each region's user rate, and reevaluated the effects of 2005 reform on the regional mobility. It turned out that the regional mobility is improved by removing the region-specific elements, suggesting that the convergence is conditional. However, we were not able to confirm if the 2005 reform had any effect on improving the regional mobility. In addition, the analysis also suggests that there are region-specific elements, other than the ones used in our research, yet to be discovered that account for the regional mobility. We note the remaining issues in section 6.

There are preceding researches on the dynamic properties of public long-term care insurance system. Some of them sought elements that affect the variables of interest, such as the service cost, the number of service users, and the insurance premium, so as to predict the future trends of these variables. Others employed panel data to seek elements that explain the time and cross-sectional variations in these variables. [Suzuki(2002), Shimizutani and Noguchi (2004), Kikuchi, Tajika, and Yui (2005), and Kikuchi (2008) calculated the future trends of the long-term care insurance system. Tajika and Kikuchi (2003), Shimizutani and Inakura(2006), Ando (2008), and the annual reports by the MHLW (2005, 2007) analyzed the causes

of regional differences in the system.] There are not many researches, however, that take the long-term care insurance system as a system of dynamical equations, as we do in this research, so as to seek the proof of convergence (or non-convergence thereof), and to analyze the degree of mobility in the standing order of regional user rates. The analytical tools employed in this research are widely used in the field of endogenous economic growth theory. These tools are useful and powerful for analyzing the dynamic properties of time and cross-sectional differences in socio-economic system. For the concept and analytical methods of the convergence and the conditional convergence, see Barro and Sala-i-Martin (2004). For the application of Markov transition matrix analysis, see Quah (1993).

## 2 . The Public Long-Term Care Insurance System in Japan; A Quick Review.

In this section, we will make a quick review on the public long-term care insurance system; The objective of the system, how a covered individual applies for and receives care services, the statistical figures of the system, preceding researches, and the objective of the 2005 reform.

### 2. 1 The Objective of the Public Long-Term Care Insurance System

The public long-term care insurance system started on April 2000. Before that, in traditional Japan, the cares for elderly people were thought to be done by family members, especially by wives. Such tradition became unsustainable because of rapidly aging demographic structure and increasing nuclear families. The increase in those who need long-term care relative to those who provide put physical and psychological pressures on many families. On the other hand, medical resources were used up by those who were not ill or sick but without enough care by family members. (The hospitalization by sociological reasons. According to the OECD health statistics, the average length of stay of Japanese inpatients is 31.2 days (2012), while the numbers are 10.1 days in France (2012), 9.2 days in Germany (2012), 7.2 days in the United Kingdom (2012), and 6.1 days in the United States (2011).) It became inevitable that the long-term care services for elderly people go public.

The new system replaced public welfare system for elderly people with public insurance system in which municipalities take role as managers. Those who contribute to the insurance system are the primary individuals (65 years or older) and the secondary insured individuals (40-64 years old). The national average monthly insurance premium paid by a primary insured individual is ¥4972 in 2014 fiscal year. The insurance premium of the secondary insured individuals is collected as part of payroll tax. For example, in 2013 fy, it is 1.55% of the salary of those covered by the health insurance association for medium-small firms. The main beneficiaries are the primary insured individuals. The secondary insured individuals also receive benefits, but in limited cases. In 2014 fy, the total cost for the long-term care services was ¥10 trillion. The service users paid 10% user fee. (The fee varies with user's income level.) After subtracting ¥0.7 trillion user fee, the remaining ¥9.3 trillion are financed by the insurance premium contributions and the public (national and local) disbursement shared at 50:50.

## 2. 2 Application Process for the Long-Term Care Services

For a primary insured individual, the application process for care services consists of the following 3 steps.

Step 1: When a primary insured individual finds herself in need for long-term care services, she applies for the certification of long-term care need by her municipality (insurer).

Step 2: The municipality, aided by committee members, decides if it grants the certification to the applicant. (Depending on the necessity, from light to the most serious, there are 7 levels of the certification.)

Step 3: If granted, the primary insured individual, aided by “care managers” about care plans, receives services where the recipient pays 10% user fee. The long-term care services are provided by private sector business entities subject to public supervision. There are in-home services, facility services, and community-based services.

## 2. 3 The Figures of the Public Long-Term Care Insurance System

As stated in the introduction, along with rapidly aging demographic structure, the figures related to the public long-term care insurance system have been increasing too. The followings are some figures reported by the MHLW to grasp the magnitude.

\*Total cost: ¥3.6 trillion (2000 fiscal year) → ¥10.0 trillion (2014 fiscal year) (+170%)

\*The number of individuals certified by municipalities for long-term care need: 2.18 million (2000 fy) → 5.64 million (2013 fy) (+159%)

\*The number of service users: 1.49 million (2000 fy) → 4.71 million (2013 fy) (+216%)

\*The national average monthly insurance premium of primary insured individual: ¥2911 (2000 fy) → ¥4972 (2014 fy) (+71%)

Because the system is managed by municipalities, there are regional differences in the figures. For example, the monthly insurance premium at the municipal level for the 6<sup>th</sup> planning period (2015-2017 fy), the highest number is ¥8686 (Tenkawa village of Nara prefecture) which is 3.1 times higher than the lowest ¥2800 (Mishima village of Kagoshima prefecture). At the prefecture level, the highest is ¥5880 of Okinawa which is 1.3 times higher than the lowest ¥4409 of Tochigi.

## 2. 4 The Causes of Regional Differences and the 2005 Reform

Many researches addressed the causes of the differences in the regional figures of public long-term care insurance system. Suzuki (2002) reported that a region with higher certification rate and the faster growth in those who need long-term care tends to have the faster growth in in-home service cost. The MHLW stated in 2007 annual report that faster increase in those who request for light support and care and faster increase in those who use in-home services cause faster increase in municipal certifications and care service users. Tajika and Kikuchi (2006) suggested that lax discipline on municipal management, incomplete task division between medical services and care services, and ineffectiveness of care services on rehabilitating users may explain the speed of increase in long-term care services. Ando (2008) found that regions with more low income individuals and more late-stage (75 years or older) old individuals have higher long-term care service cost. Tajika and Kikuchi (2003), the MHLW annual report (2005), and Abrai (2006) found that a region with more facilities tends to have higher cost because it induces more demand for facility services

(which cost more relative to in-house services). These researches suggest the importance of {shift from facility to in-home services, rigorous discipline on municipal management, prevention against long-term care need}.

In accordance with the implications of these researches, Japanese government took the following measures to remedy the regional differences in the 2005 reform.

\*Tighter municipal discipline on the review process for certification.

\*Less biased distribution of facilities across regions by limiting the total number.

\*Induce private business entities to supply relatively more in-home services to those users with medium-serious conditions.

\*Facility service users are made to pay residence and meal cost.

\*Introduce community-based services that aim to prevent elderly people from being in need for long-term care.

In the following sections, we will analyze the dynamic properties of regional differences in long-term care insurance system and the effect of the 2005 reform.

### 3 . Theoretical Model Analyses of the Public Long-Term Care Insurance System

As we saw in the previous section, there are wide differences in regional figures of the public long-term care insurance system. It is important to predict the future trend of the system because it helps those who have concerns in the system. For example, the prediction will help municipalities as insurers to evaluate the fiscal impact of the system, which consequently will affect insured individuals. For this purpose, we construct a theoretical model of the public long-term care insurance system and analyze dynamical properties of “user rate” which is defined as the ratio of service users among insured individuals. The theoretical model will be used to derive a convergence hypothesis with respect to regional user rates.

#### 3. 1 Theoretical Model Analyses

The Japanese public long-term care insurance system will be modeled as follows. There are  $I = 47$  regions (prefectures). For  $\{i = 1, 2, \dots, I, t = 0, 1, 2, \dots\}$ , let  $L_{i,t}$  be the number of primary insured individuals (65 years or older) of region  $i$  in period  $t$ . In the following, the region subscript “ $i$ ” will be omitted unless necessary. Let  $n$  be the gross rate of change in the number of primary insured individuals, reflecting the number of those who were 64 years old in the previous period and the number of those who moved from other regions. Let  $\delta$  be the “depreciation” rate of primary insured individuals, reflecting the number of deceased and the number of those who moved to other regions. Then, the net growth of the number of primary insured individuals is expressed as follows.

$$L_{i,t+1} = (1 + n - \delta)L_{i,t}, \quad t = 0, 1, 2, \dots \quad (3.1)$$

Suppose the public long-term care insurance system is introduced at the beginning of period zero. Let  $X_0$  be the number of service users. Under the current system,  $X_0$  is determined through the following 4 steps. (See section 2. 2.)

Step 1: Let  $p$  be the probability that an insured individual find herself in need for long-term care services (need for care rate). Then at  $t = 0$ , among the primary insured individuals  $L_0$ ,  $p \times L_0$  is the number of individuals who find themselves in need for long-term care services.  $(1 - p) \times L_0$  is the number of individuals who do not.

Step 2: Let  $q$  be the probability of applying for municipal certification for long-term care need by an individual in step 1 (application rate). Then,  $q \times p \times L_0$  is the number of individuals applying for the municipal certifications.  $(1 - q) \times p \times L_0$  is the number of individuals not applying.

Step 3: Let  $r$  be the probability that a municipality as insurer grants certification to an applicant in step 3. Then,  $r \times q \times p \times L_0$  is the number of individuals who are granted municipal certifications (certification rate).  $(1 - r) \times q \times p \times L_0$  is the number of individuals who are not granted.

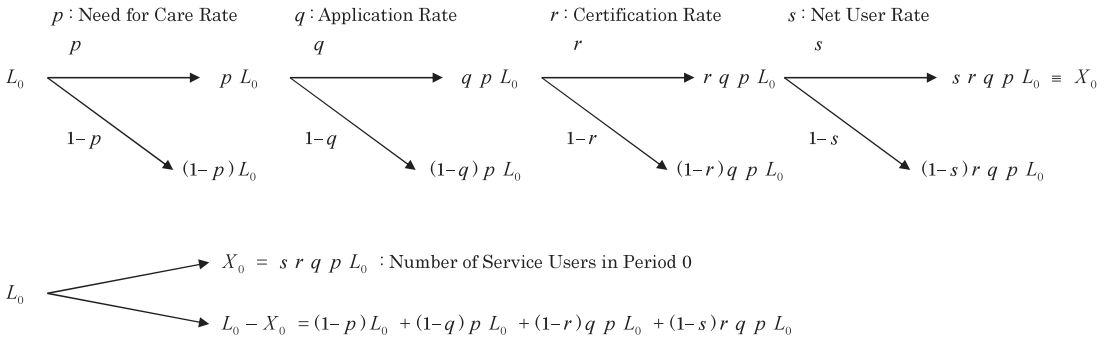
Step 4: Let  $s$  be the probability that an individual with municipal certification use public long-term care service (net user rate). Then  $s \times r \times q \times p \times L_0$  is the number of those who use services.  $(1 - s) \times r \times q \times p \times L_0$  is the number of those who do not.

As a result of step 1 - step 4, in a region at  $t = 0$ , the number of individuals who use public long-term care services is

$$X_0 = p q r s L_0. \quad (3.2)$$

The rest  $L_0 - X_0 = (1 - p) L_0 + (1 - q) p L_0 + (1 - r) q p L_0 + (1 - s) r q p L_0$  is the number of individuals who do not use public long-term care service. Instead, they will choose from such alternatives as private care services, public or private medical services, no services at all and stay as they are, etc. Figure 3.1 depicts the flow process that determines  $X_0$ .

Figure 3.1 Application Process for the Long-Term Care Services



In the next period  $t = 1$ , the number of service users  $X_1$  is calculated as follows. The number of primary insured individuals in  $L_1$  is decomposed as follows.

$$L_1 = (1 + n - \delta) L_0 = n L_0 + (1 - \delta)(X_0 - L_0) + (1 - \delta) X_0 \quad (3.3)$$

In (3.3),  $n L_0$  is the number of new primary insured individuals,  $(1 - \delta)(X_0 - L_0)$  is the survivors among non-users, and  $(1 - \delta) X_0$  is the survivors among service users. The logic used to derive  $X_0$  in  $t = 0$  is also applicable to derive  $X_1$  as follows. Among the new primary insured individuals,  $p q r s \times n L_0$  individuals use

services in  $t = 1$ . Among the surviving non users,  $pqr s \times (1 - \delta)(X_0 - L_0)$  individuals use services in  $t = 1$ . Therefore, the number of service users  $X_1$  is calculated as follows.

$$\begin{aligned} X_1 &= pqr s nL_0 + pqr s(1 - \delta)(X_0 - L_0) + (1 - \delta)X_0 \\ &= (1 - \delta)(1 - pqr s)X_0 + pqr s L_1 \end{aligned} \quad (3.4)$$

Equation (3.1) is used to derive the last line. (In the derivation of (3.4), we assumed that once an individual begins to use long-term care services, the individual keeps using the services in subsequent years. This assumption reflects the observation by Tajika and Kikuchi (2006) about the inability of public long-term care services to rehabilitate individuals under care. If insured individuals go back and forth between “under care” state and “out of care (rehabilitated)” state, then the dynamical analyses will be much more complex, and beyond the scope of this research.) Equation (3.4) holds in any year  $t = 0, 1, 2, \dots$ . Define the user rate  $x_t$  by

$$x_t \equiv X_t / L_t . \quad (3.5)$$

By dividing both sides of equation (3.4) by  $L_t$ , we have the following linear first-order difference equation with respect to user rate  $x_t$ .

$$x_{t+1} = \left( \frac{(1 - \delta)(1 - pqr s)}{1 + n - \delta} \right) x_t + pqr s \quad (3.6)$$

Equation (3.1) is used again to derive (3.6). If  $\{p, q, r, s, n, \delta\}$  are constant parameters, then in (3.6), the slope is  $0 < (1 - \delta)(1 - pqr s)/(1 + n - \delta) < 1$ . Therefore, the dynamical system (3.6) is globally stable. That is, for any  $x_0 > 0$ , the sequence of user rate  $\{x_t; t = 0, 1, 2, \dots\}$  monotonically converges to a unique steady state  $x^*$  where

$$x^* \equiv pqr s / [1 - \{(1 - \delta)(1 - pqr s)/(1 + n - \delta)\}]. \quad (3.7)$$

In addition, it can be shown that, for any two regions  $i$  and  $j$ ,

$$\text{if } x_{i,0} \begin{pmatrix} > \\ = \\ < \end{pmatrix} x_{j,0} , \text{ then } \frac{x_{i,t+1} - x_{i,t}}{x_{i,t}} \begin{pmatrix} < \\ = \\ > \end{pmatrix} \frac{x_{j,t+1} - x_{j,t}}{x_{j,t}} , t = 0, 1, 2, \dots . \quad (3.8)$$

These observations imply that the regional user rates  $\{x_{i,t}; i = 1, 2, \dots, I, t = 0, 1, 2, \dots\}$  exhibit “convergence” to the same steady state  $x^*$  if all the regions have the same values of parameters  $\{p, q, r, s, n, \delta\}$ .

The values of parameters, however, may be different across regions. For example, the MHLW 2005 annual report documented the regional differences in municipal certification rate  $r$ . We also expect that the parameter values are region-specific because of various socio-economic reasons. If the parameter values in equation (3.6) are different across regions, then each region's user rate  $x_{i,t}$  may converge to region-specific steady state  $x_i^*$ . That is, the user rate convergence is conditional on each region's parameter values. In the next section, we analyze the data of regional user rates to investigate the following two hypotheses; [(Unconditional) Convergence Hypotheses] All the regional user rates  $\{x_{i,t}; i = 1, 2, \dots, I, t = 0, 1, 2, \dots\}$



converges to the same steady state  $x^*$ .

[Conditional Convergence Hypotheses] Each regional user rates  $\{x_{i,t}; i = 1, 2, \dots, I, t = 0, 1, 2, \dots\}$  converges to the region-specific steady state  $x_i^*$ .

We add some comments on the dynamic properties of equation (3.6). The government reviews the long-term care insurance system and conduct major reforms at every five years. For example, the 2005 reform may have affected the dynamical system (3.6) as follows.

( i ) The 2005 reform made the facility service users pay residence and meal cost. This change might have depressed the demand for long-term care services, and hence lowered the net user rate  $s$ .

( ii ) The 2005 reform enhanced the efforts of preventing insured individuals from being in need for long-term care services. The prevention efforts might have lowered the need for care rate  $p$ .

( iii ) The 2005 reform imposed more rigorous discipline on the review process for certification by municipalities. This might have lowered the certification rate  $r$ .

( iv ) As the number of service users increases, the public long-term care insurance system may gain wider societal recognition. As a result, those who previously regarded the public long-term care services as public welfare with some stigma will be less reluctant to apply for the services. The prevalence of the system, hence, may increase the application rate  $q$ . (The traditional view about long-term care for elderly people may change as service users increase and as people learn more about the system. In this case, the application rate  $q$  in equation (3.6) may not be a constant parameter, but dependent on user rate  $x$ . If it is so, then equation (3.6) is no longer a linear equation. Instead, equation (3.6) may generate a complex path for the use rate sequence  $\{x_t; t = 0, 1, 2, \dots\}$ ).

( v ) The differences in long-term care insurance system across municipalities may induce each insured individual to seek a region with better services and lower cost. This may affect each region's net growth rate  $n - \delta$  of insured individuals.

By differentiating the steady state user rate  $x^*$  (equation (3.7)) with respect to the parameters  $\{p, q, r, s, n, \delta\}$ , we verify the following comparative static properties.

$$x^*(\overset{+}{p}, \overset{+}{q}, \overset{+}{r}, \overset{+}{s}, \overset{-}{n}, \overset{-}{\delta}) \quad (3.9)$$

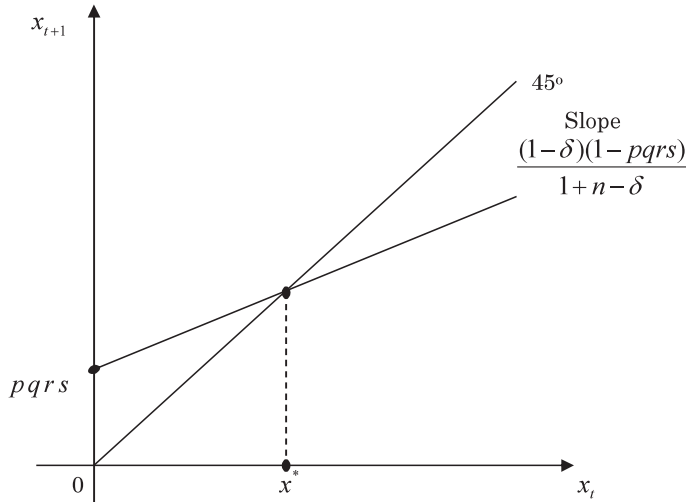
In (3.9), the “+” or “-” sign above each parameter indicates the effect of an increase in the parameter value on the steady state user rate  $x^*$ . An increase in the need for care rate  $p$ , an increase in the application rate  $q$ , an increase in the certification rate  $r$ , or an increase in the net user rate  $s$  obviously causes the steady state user rate  $x^*$  to increase. Although the net growth rate of primary insured individuals is expressed as  $n - \delta$ , an increase in the gross growth rate  $n$  or an increase in the depreciation rate  $\delta$  causes  $x^*$  to decrease because of the following reasons. An increase in the gross growth rate  $n$  causes the steady state value of the user rate  $x_t = X_t/L_t$  to decrease simply because of the faster increase in denominator  $L_t$ . On the other hand, the increase in the depreciation rate  $\delta$  has two effects on the steady state user rate  $x^*$ . While it causes the number of primary insured individuals to decrease, it also causes the number of surviving service users to decrease. The latter effect dominates the former because the latter works at the cumulative stock level while the former at the flow level.

Figure 3.2 is a phase diagram of equation (3.6). The horizontal axis measures  $x$ , and the vertical axis

measures  $x_{t+1}$ . If the parameters  $\{p, q, r, s, n, \delta\}$  are constant, then the graph of (3.6) is depicted as an upward-sloping straight line with intercept  $pqrs$  at the vertical axis. Because the slope is  $0 < (1 - \delta)(1 - pqrs)/(1 + n - \delta) < 1$ , the dynamical system (3.6) has a unique and globally stable steady state at the intersection of the graph of (3.6) and 45-degree line in figure 3.2. That is, given any initial user rate  $x_0 > 0$ , the sequence of user rate  $\{x_t; t = 0, 1, 2, \dots\}$  generated by equation (3.6) monotonically converges to the steady state user rate  $x^*$ . Furthermore, if the initial user rate  $x_{i,0}$  of region  $i$  is smaller than  $x_{j,0}$  of region  $j$ , then the growth rate of region  $i$ 's user rate is larger than that of region  $j$  for all the subsequent periods, i.e.,

$$\text{if } x_{i,0} < x_{j,0}, \text{ then } \frac{x_{i,t+1} - x_{i,t}}{x_{i,t}} > \frac{x_{j,t+1} - x_{j,t}}{x_{j,t}}, \quad t = 0, 1, 2, \dots \quad (3.10)$$

Figure 3.2 Phase Diagram of Equation (3.6)



The effects of changes in the value of parameters  $\{p, q, r, s, n, \delta\}$  on the steady state user rate  $x^*$  can be analyzed by using figure 3.2. In the figure, an increase in the need for care rate  $p$ , an increase in the application rate  $q$ , an increase in the certification rate  $r$ , or an increase in the net user rate  $s$  causes the vertical intercept  $pqrs$  to increase and the slope  $(1 - \delta)(1 - pqrs)/(1 + n - \delta)$  to decrease. The combined effect is a rise in the intersection of the graph of (3.6) and 45-degree line, i.e., an increase in the steady state user rate  $x^*$ . An increase in the gross growth rate  $n$  or an increase in the depreciation rate  $\delta$  does not affect the vertical intercept  $pqrs$ . However, it causes the slope  $(1 - \delta)(1 - pqrs)/(1 + n - \delta)$  to decrease. As a result, the intersection of the graph of (3.6) and 45-degree line decreases, i.e., the steady state user rate  $x^*$  decreases. These statements are also verified by simple calculus. For example,  $\partial[(1 - \delta)(1 - pqrs)/(1 + n - \delta)]/\partial\delta = -(1 - pqrs)n/(1 + n - \delta)^2 < 0$  provided  $n > 0$ .

Table 3.1 summarizes the effects of the 2005 reform on the steady state user rate  $x^*$ . The table suggests that the 2005 reform tried to stabilize the fiscal management of public long-term care insurance system against rapid increase in service users and service cost.

Table 3.1 The Effects of the 2005 Reform on the Steady State User Rate  $x^*$

Enhanced Senility Prevention Effort	$p \downarrow \Rightarrow x^* \downarrow$
Charging Residence and Meal Cost	$s \downarrow \Rightarrow x^* \downarrow$
Tightening Discipline on Municipalities	$r \downarrow \Rightarrow x^* \downarrow$
Wider Recognition of the System	$q \uparrow \Rightarrow x^* \uparrow$

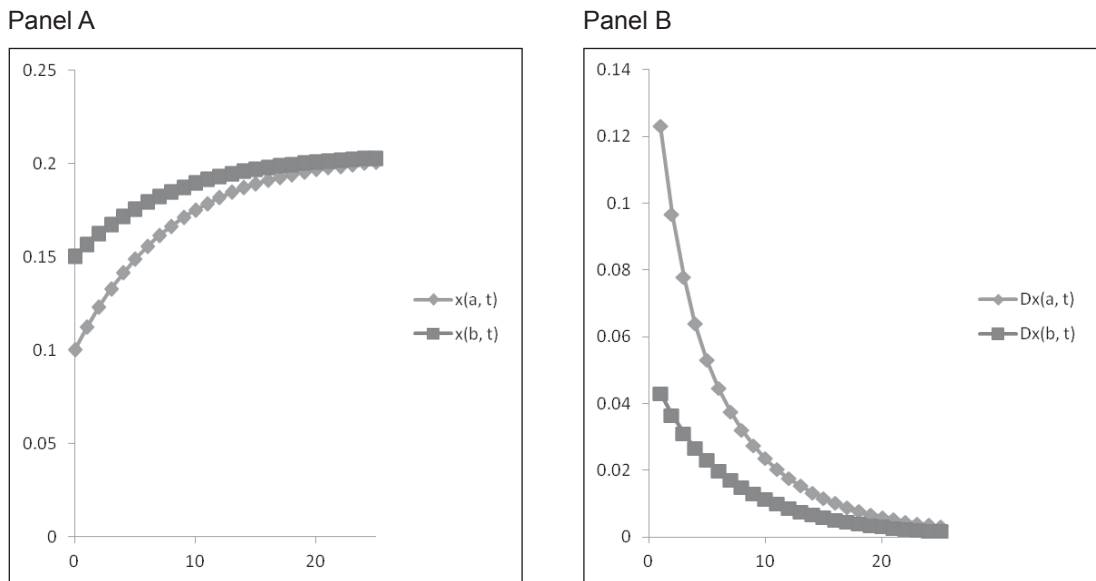
$$x^*(p, q, r, s, n, \delta)$$

$p$ : Need for Care Rate,  $q$ : Application Rate,  $r$ : Certification Rate,  $s$ : Net User Rate,  $n$ : Gross Growth Rate of Insured Individuals,  $\delta$ : Depreciation Rate

### 3.2 Numerical Example

Panel A of figure 3.3 depicts transitional paths of two regions,  $a$  and  $b$ , such that the initial user rate of region  $a$ ,  $x(a, 0)$ , is smaller than that of region  $b$ ,  $x(b, 0)$ . In addition, we assume that both of them are smaller than the steady state user rate  $x^*$ , i.e.,  $x(a, 0) < x(b, 0) < x^*$ . The parameter values are same for both regions, set at  $\{p = 0.25, q = 0.8, r = 0.15, s = 0.8, n = 0.1, \delta = 0.05\}$ . Given these values, equation (3.7) implies the steady state user rate  $x^* = 0.2052$ . The initial user rates are set at  $x(a, 0) = 0.1$  and  $x(b, 0) = 0.15$ . Panel B of figure 3.3 depicts the growth rates of two regions  $\{[(x(a, t + 1) - x(a, t))/x(a, t)], [(x(b, t + 1) - x(b, t))/x(b, t)]; t = 0, 1, 2, \dots\}$ . These figures show that the transitional paths of user rates generated by the dynamical system (3.6) monotonically converge to the steady state, and the growth rate of user rate is higher (lower) for the region with lower (higher) initial user rate.

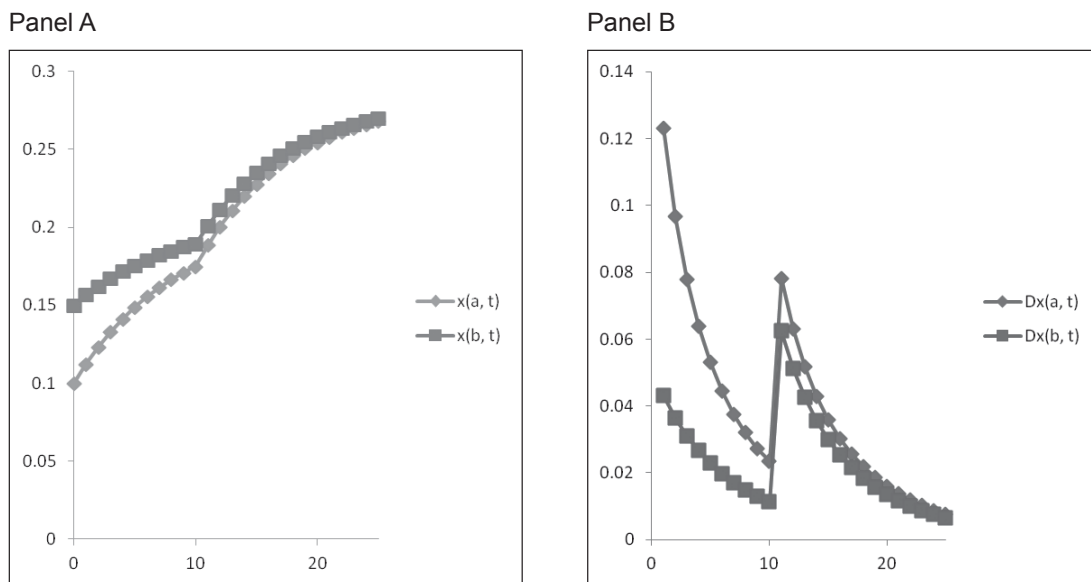
Figure 3.3 Transitional Paths of User Rates: Numerical Example



$\{x(a, 0) = 0.1, x(b, 0) = 0.15, p = 0.25, q = 0.8, r = 0.15, s = 0.8, n = 0.1, \delta = 0.05, x(a, 0) = 0.1, x(b, 0) = 0.15\}$

Panel A of figure 3.4 depicts the effects of a change in parameter value on the transitional path of user rates. For periods  $t = 0, 1, 2, \dots, 10$ , we assume the same assumptions as before, i.e.,  $\{p = 0.25, q = 0.8, r = 0.15, s = 0.8, n = 0.1, \delta = 0.05\}$  and  $\{x(a, 0) = 0.1, x(b, 0) = 0.15\}$ , hence  $x^* = 0.2052$ . We also assume that at  $t = 11$  the application rate  $q$  increases from 0.8 to 0.9 and stays at the higher value thereafter which implies the new steady state  $x^* = 0.2817$ . Panel A of figure 3.4 shows that the transitional paths, at the time of shock  $t = 11$ , begin to converge to the new and higher steady state. As depicted by panel B of figure 3.4, the change causes a temporary increase in growth rates of both regions.

Figure 3.4 Transitional Paths of User Rates (Shock at  $t = 10$ ): Numerical Example



$\{x(a, 0) = 0.1, x(b, 0) = 0.15, p = 0.25, r = 0.15, s = 0.8, n = 0.1, \delta = 0.05, x(a, 0) = 0.1, x(b, 0) = 0.15\}$   
 $\{q = 0.8, t = 0, 1, 2, \dots, 10\}, \{q = 0.9, t = 11, 12, \dots\}$

### 3.3 Data Properties

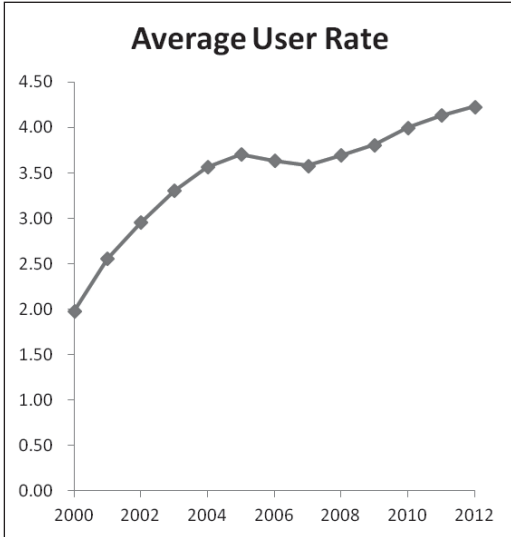
In this section, we look at the data of public long-term care insurance system for the properties of average user rate and regional differences. For the analyses, we use the data provided by the Japan Ministry of Health, Labor, and Welfare. There are cautions on interpreting the data. See appendix at the end of paper for details.

In figure 3.5, panel A depicts the graph of average user rate of 47 Japanese regions (prefectures), and panel B depicts the graph of growth rate of average user rate. These graphs show that the average user rate increased between 2000 and 2005 at diminishing growth rate. After the temporal decline in 2006 and 2007, the average user rate began to grow again, but at diminishing growth rate. There seems to be a structural change before and after the 2005 reform. Figure 3.6 is the graph of coefficient of variation of the regional user rates, and figure 3.7 is the graph of max ÷ min ratio of the regional user rates. The coefficient of variation slightly increased between 2000 and 2005. After 2006, it did not show clear trend. The max ÷ min ratio, on the other hand, showed declining trend throughout the data periods. (The spikes in figure 3.6 and figure 3.7 are caused by irregular movement in Niigata's user rate which plummeted in one and only

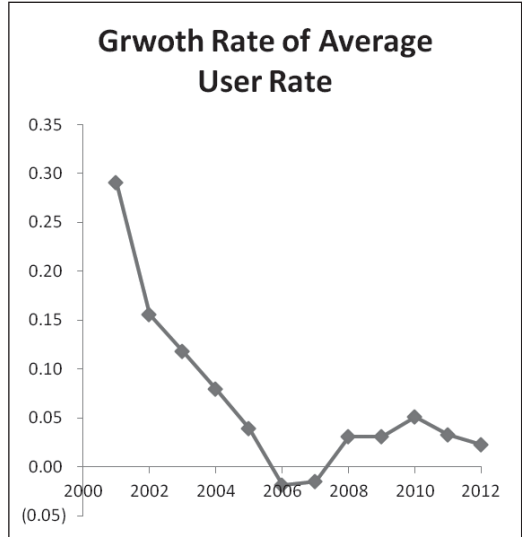
one year 2007.) Figure 3.8 depicts the graph of Gini coefficient of the regional user rates. Like figure 3.7 which depicts the graph of max ÷ min ratio, the Gini coefficient showed declining trend throughout the data periods, suggesting the diminishing regional differences in user rates.

Figure 3.5 Average User Rate of 47 Japanese Prefectures

Panel A

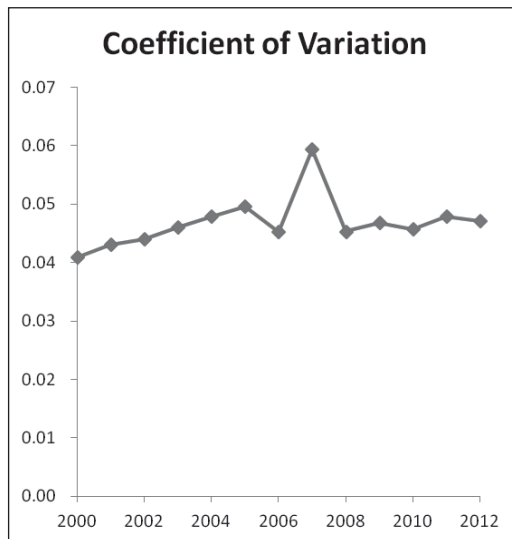


Panel B



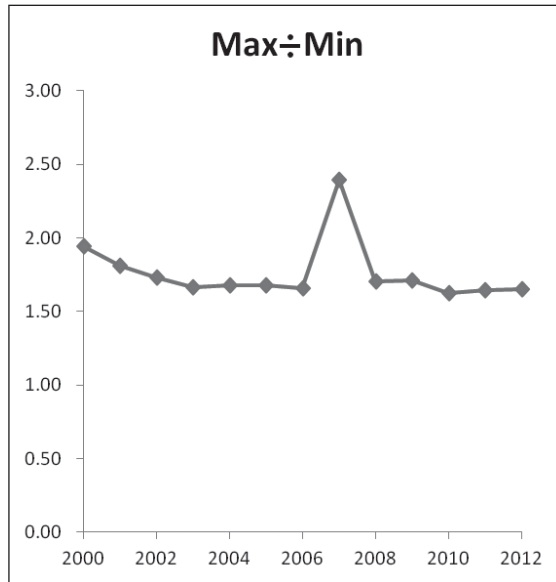
Data Source: Japan Ministry of Health, Labor, and Welfare

Figure 3.6 Coefficient of Variation of Regional User Rates



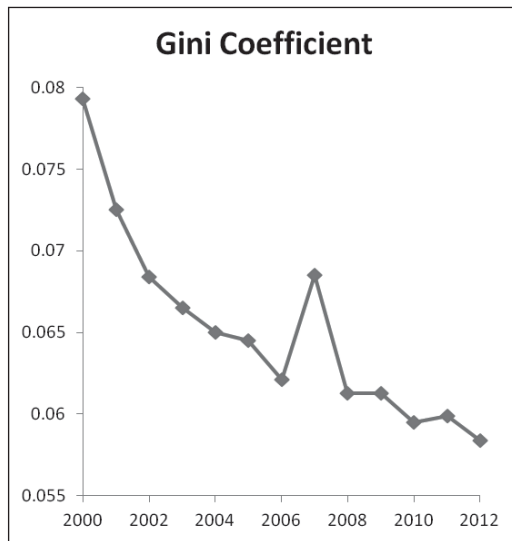
Data Source: Japan Ministry of Health, Labor, and Welfare

Figure 3.7 Max ÷ Min Ratio of Regional User Rates



Data Source: Japan Ministry of Health, Labor, and Welfare

Figure 3.8 Gini Coefficient of Regional User Rates



Data Source: Japan Ministry of Health, Labor, and Welfare

Next, in order to analyze the variations in the standing order (high and low) of regional user rates, we sorted the 47 regions (prefectures) according to each region's user rate, and divided them into 5 groups { I (7 regions), II (10), III (10), IV (10), V (10)}. Group I consist of 7 regions with the highest user rates, group II consists of 10 regions with second highest user rates, and so on. Group V consists of 10 regions with the lowest user rates. Then, for 2000-2012, we calculated the mean user rate and the annual rate of change

for each group. The results are summarized in table 3.2. The table reveals the following properties;

( i ) The movement of each group's use rate resembles the movement of the average user rate. That is, they grew but at diminishing rate between 2000 and 2005, declined temporarily in 2006 and 2007, then started to grow again after 2008 at diminishing rate. There seems to be a structural change before and after the 2005 reform.

( ii ) In the first half (2000-2005),the years before the 2005 reform, the higher (lower) is a group's user rate, the slower (faster) is the subsequent growth of the group's user rate, i.e., the regional user rates seem to converge. For example, in 2000, group I's user rate is 2.43 and group V's use rate is 1.62. Between 2000 and 2001, the rate of change in group I's user rate is 0.27 while that of group V is 0.31. Between 2000 and 2005, the average annual growth rates are higher (lower) for the groups with lower (higher) user rate. Such a convergence in regional user rates is not so obvious in the second half (2006-2012), the years after the 2005 reform, although it seems to hold for the groups with higher user rates. In figure 3.9, panel A depicts the graphs of group I's user rate and group V's user rate, and panel B depicts the graphs of growth rate of group I's user rate and that of group V's user rate. Compare and notice the resemblance between figure 3.9 (actual data) and figure 3.4 (calibrated data). The comparison of these figures seems to suggest that the convergent paths of user rates were affected by the 2005 reform. The 2005 reform might have altered the steady state, and initiated convergence to the new steady state.

**Table 3.2 Regional User Rates of Groups { I , II , III , IV , V }**  
**Regional User Rates**

	Group I	Group II	Group III	Group IV	Group V
2000	2.428	2.180	1.971	1.841	1.619
2001	3.075	2.789	2.560	2.394	2.120
2002	3.499	3.214	2.988	2.769	2.471
2003	3.891	3.597	3.333	3.096	2.783
2004	4.193	3.879	3.571	3.356	3.024
2005	4.348	4.024	3.714	3.493	3.138
2006	4.262	3.910	3.662	3.437	3.098
2007	4.229	3.871	3.626	3.411	2.966
2008	4.321	3.955	3.724	3.518	3.138
2009	4.441	4.087	3.841	3.638	3.227
2010	4.618	4.296	4.055	3.830	3.395
2011	4.779	4.444	4.190	3.938	3.514
2012	4.873	4.521	4.289	4.061	3.590

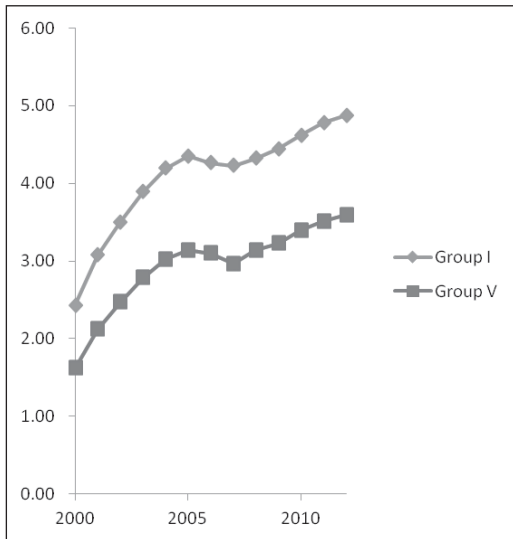
Growth Rate of Regional User Rates

	Group I	Group II	Group III	Group IV	Group V
2000					
2001	0.267	0.279	0.299	0.300	0.310
2002	0.138	0.152	0.167	0.157	0.165
2003	0.112	0.119	0.115	0.118	0.126
2004	0.077	0.079	0.071	0.084	0.087
2005	0.037	0.037	0.040	0.041	0.038
2006	-0.020	-0.028	-0.014	-0.016	-0.013
2007	-0.008	-0.010	-0.010	-0.008	-0.042
2008	0.022	0.022	0.027	0.031	0.058
2009	0.028	0.033	0.031	0.034	0.028
2010	0.040	0.051	0.056	0.053	0.052
2011	0.035	0.034	0.033	0.028	0.035
2012	0.020	0.017	0.023	0.031	0.022

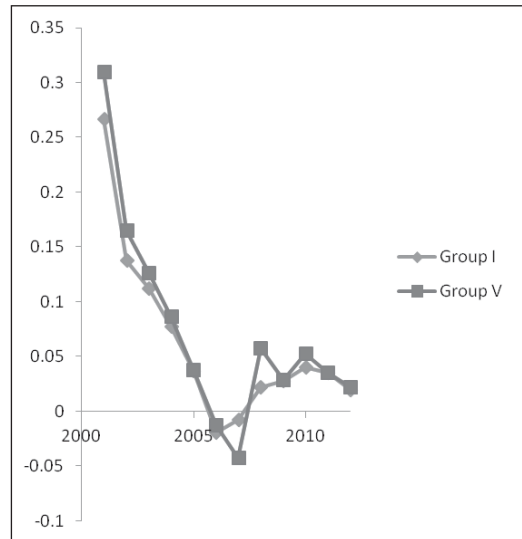
Data Source: Japan Ministry of Health, Labor, and Welfare

Figure 3.9 User Rates of Group I and Group V

Panel A User Rates



Panel B Growth Rates of User Rates



Data Source: Japan Ministry of Health, Labor, and Welfare

Although the regional user rates seem to exhibit a convergence property, it might not be an unconditional convergence. As we saw in the theoretical model analysis of the user rate, if each region has different parameter values, then each region's user rate may converge to region-specific steady state. If the convergence is conditional on region-specific elements, then the standing order (high and low) of regional



user rates may not be variable. In fact, as shown in table 3.3, which is a list of 5 regions (prefectures) with the higher user rates and 5 regions with the lowest between 2000 and 2012, there was a small degree of variation in the standing order. For example, Wakayama, Tokushima, and Hiroshima belonged to the top 5 regions for all but 3 years between 2000-2012. Especially, Wakayama had the highest user rate in 2003 and 2005, and for all the years in the second half (2006-2012). On the other hand, Tochigi, Ibaraki, Chiba, and Saitama, all of them are located in Kanto area, belonged to the bottom 5 regions for all the sample years.

Table 3.3 Regional User Rates: The Highest 5 Regions and the Lowest 5 Regions

STANDING	2000	2001	2002	2003	2004	2005
1	Kagoshima	Kagoshima	Kagoshima	Wakayama	Tokushima	Wakayama
2	Aomori	Aomori	Kyoto	Kagoshima	Wakayama	Tokushima
3	Oita	Okinawa	Okinawa	Tokushima	Hiroshima	Hiroshima
4	Okinawa	Hiroshima	Hiroshima	Hiroshima	Oita	Oita
5	Hiroshima	Kyoto	Aomori	Kyoto	Kyoto	Nagasaki
43	Yamanashi	Yamanashi	Yamanashi	Hokkaido	Hokkaido	Hokkaido
44	Tochigi	Tochigi	Tochigi	Tochigi	Tochigi	Tochigi
45	Ibaraki	Chiba	Chiba	Chiba	Chiba	Chiba
46	Chiba	Saitama	Saitama	Saitama	Saitama	Saitama
47	Saitama	Ibaraki	Ibaraki	Ibaraki	Ibaraki	Ibaraki

STANDING	2006	2007	2008	2009	2010	2011	2012
1	Wakayama	Wakayama	Wakayama	Wakayama	Wakayama	Wakayama	Wakayama
2	Tokushima	Tokushima	Tokushima	Tokushima	Tokushima	Tokushima	Osaka
3	Hiroshima	Hiroshima	Shimane	Nagasaki	Nagasaki	Osaka	Tokushima
4	Aomori	Aomori	Hiroshima	Shimane	Hiroshima	Nagasaki	Shimane
5	Ehime	Ehime	Ehime	Ehime	Shimane	Shimane	Nagasaki
43	Hokkaido	Tochigi	Aichi	Aichi	Aichi	Shizuoka	Shizuoka
44	Tochigi	Chiba	Tochigi	Tochigi	Tochigi	Tochigi	Tochigi
45	Chiba	Ibaraki	Chiba	Chiba	Chiba	Chiba	Chiba
46	Saitama	Saitama	Ibaraki	Ibaraki	Ibaraki	Saitama	Saitama
47	Ibaraki	Niigata	Saitama	Saitama	Saitama	Ibaraki	Ibaraki

Data Source: Japan Ministry of Health, Labor, and Welfare

Despite the small variation in the standing order of regional user rates, the 2005 reform might have affected each region's mobility across the ladder of standing order because its objective is to remedy the regional differences. Therefore, if the reform had the implied effects, if any, we could expect the increased mobility of the standing order in the second half (2006-2012) relative to the first half (2000-2005). The objective of the next section, hence, is to evaluate if the 2005 reform did remedy the regional differences and alleviated the standing order inertia.

#### 4 . Mobility Analyses of Regional User Rates' Standing Order

In this section, we develop an index for measuring the degree of regions' mobility across the ladder of user rates standing order (high and low) to see if the 2005 reform had the implied effects. The index, which is based on Markov transition matrixes, is calculated by the following 4 steps.

Step 1: Let  $\{x(i, t); i = 1, 2, \dots, 47, t = 2000, 2001, \dots, 2012\}$  stands for the user rate of region  $i$  in year  $t$ . For each year  $t$ ,  $\{x(i, t); i = 1, 2, \dots, 47\}$  is sorted from the highest to the lowest, and divided into 5 groups  $\{I (7 \text{ regions}), II (10), III (10), IV (10), V (10)\}$  as we did in section 3.3.

Step 2: We construct a Markov transition matrix of size  $5 \times 5$  from 2000 to 2001, denoted as  $P_{0,1}$ , as follows. The (1, 1) element of the matrix, denoted as  $P_{0,1}(1, 1)$ , is the number of regions of group I in 2000 that remained in group I in the next year 2001 divided by the group size (7 regions). For example, among seven regions of group I in 2000, if two regions move to the other groups while five regions stay, then  $P_{0,1}(1, 1) = 5/7$ . The other elements  $\{P_{0,1}(1, j); j = 2, 3, 4, 5\}$  of the first row of  $P_{0,1}$  imply the number of regions of group I in 2000 that moved to group  $j$  in 2001 divided by group I's size. Generally, we denote  $\{P_{t,t+1}(i, j); i, j = 1, 2, 3, 4, 5, t = 2000, 2001, \dots, 2011\}$  as the number of regions of group  $i$  in year  $t$  that moved to group  $j$  in year  $t + 1$  divided by group  $i$ 's size.

Step 3. We calculate the average Markov transition matrixes for the first half by:

$$P_A \equiv (1/5) \sum_{t=2000}^{2004} P_{t,t+1} \quad (4.1)$$

and for the second half by

$$P_B \equiv (1/7) \sum_{t=2005}^{2011} P_{t,t+1} \quad (4.2)$$

The average Markov transition matrixes  $\{P_A, P_B\}$  have the following properties.

( i ) By construction, the five elements of each row of  $P_{t,t+1}$  add up to one, i.e.,

$$\sum_{j=1}^5 P_{t,t+1}(i, j) = 1 \text{ for all } i \in \{1, 2, 3, 4, 5\} \text{ and for all } t \in \{2000, 2001, \dots, 2011\}. \quad (4.3)$$

By definition, the same property also holds for the average Markov transition matrixes  $\{P_A, P_B\}$ . This implies that  $\{P_A, P_B\}$  are probability matrixes.

( ii ) For  $k = 1, 2, 3, \dots$ , the  $k$ -th powered average Markov transition Matrixes  $\{(P_A)^k, (P_B)^k\}; k = 1, 2, 3, \dots\}$  are also probability matrixes. We use the average Markov transition matrixes to evaluate the degree of variation in the standing order of regional user rates as follows. Suppose, although counter factual, there was no variation in the standing order of regional user rates in the first half, i.e., no region moved from one group to the others in any years between 2000 and 2005. Then, each Markov transition matrix  $\{P_{t,t+1}; t = 2000, 2001, \dots, 2004\}$  is a  $5 \times 5$  unit matrix, so are the average matrix  $P_A$  and its  $k$ -th power  $\{(P_A)^k; k = 1, 2, 3, \dots\}$ . On the other hand, if there are regions that moved from one group to the others in the first half, then some of the Markov transition matrixes have non-zero non-diagonal elements, so does the average matrix  $P_A$ . In this case, each row of the  $k$ -th powered average Markov transition Matrix  $(P_A)^k$  may converge

to the “uniform” distribution  $\{7/47, 10/47, 10/47, 10/47, 10/47\}$  as  $k$  becomes larger. For example, the first row of  $(P_A)^k$ , denoted as  $\{(P_A)^k(1, j); j = 1, 2, 3, 4, 5\}$ , expresses the hypothetical probability distribution for a region in group I's whereabouts among 5 groups  $k$  years later if the degree of variation in the first half continues. Then, the convergence of the first row to the “uniform” distribution implies that, even if the degree of variation in the standing order of regional user rates is small in the short run, it will be variable in the long run. In which group a region will be in the long run is a random event described by the “uniform” distribution.

Step 4: The degree of variation in the long run, may be different in the first half and the second half because of the 2005 reform which aimed to remedy the regional differences in user rates. To compare the degree of variation before and after the 2005 reform, we calculated the distances between each row of the  $k$ -th powered average Markov transition matrixes  $\{(P_A)^k, (P_B)^k; k = 1, 2, 3, \dots\}$  and the “uniform” distribution as follows. For  $\{k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$ ,

$$V_A(k, i) = [(P_A)^k(i, 1) - (7/47)]^2 + [(P_A)^k(i, 2) - (10/47)]^2 + \dots + [(P_A)^k(i, 5) - (10/47)]^2, \quad (4.4)$$

$$V_B(k, i) = [(P_B)^k(i, 1) - (7/47)]^2 + [(P_B)^k(i, 2) - (10/47)]^2 + \dots + [(P_B)^k(i, 5) - (10/47)]^2. \quad (4.5)$$

For example,  $V_A(k, 1)$  is a distance between the first row of the  $k$ -th powered average Markov transition matrixes  $(P_A)^k$  and the “uniform” distribution  $\{7/47, 10/47, 10/47, 10/47, 10/47\}$ . Then, the standing order convergence of regional user rates in the first half and that in the second half may be defined as follows.

$$\lim_{k \rightarrow \infty} V_A(k, i) = 0 \text{ for all } i = 1, 2, 3, 4, 5 \quad (4.6)$$

$$\lim_{k \rightarrow \infty} V_B(k, i) = 0 \text{ for all } i = 1, 2, 3, 4, 5 \quad (4.7)$$

We expect the quicker convergence in the second half than the first half if the 2005 reform had the implied effects.

By using the MHLW data, the average Markov transition matrixes of the first half and the second half are calculated as follows.

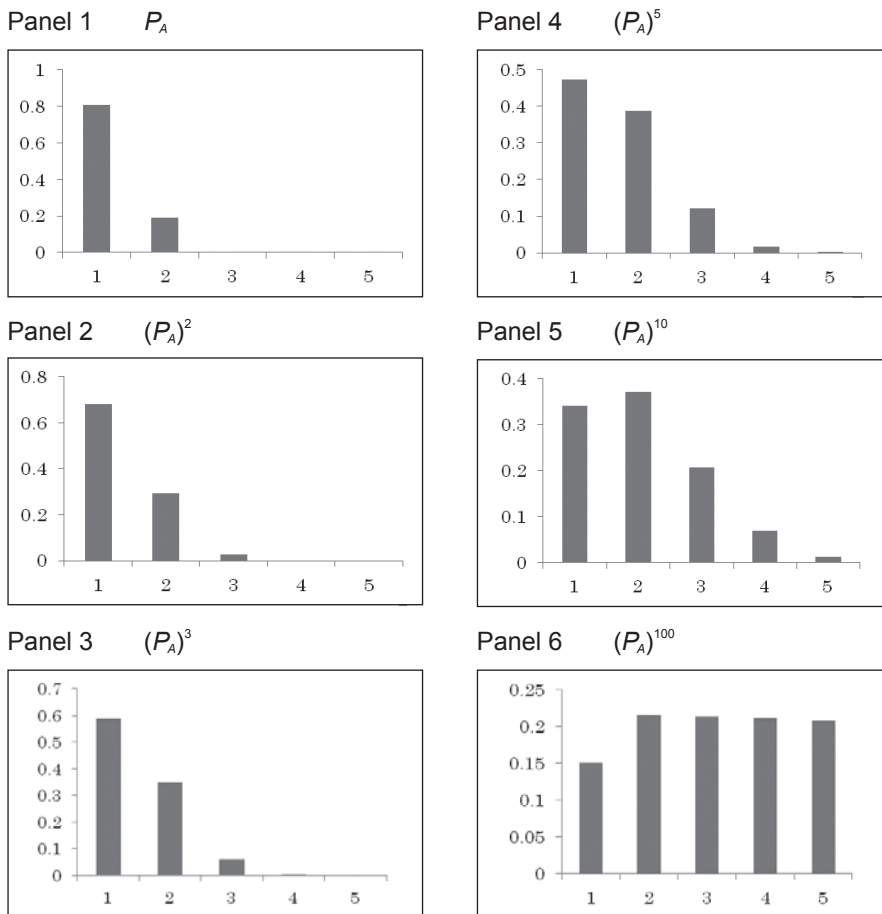
$$P_A = \begin{pmatrix} 0.81 & 0.19 & 0 & 0 & 0 \\ 0.133 & 0.733 & 0.133 & 0 & 0 \\ 0 & 0.133 & 0.767 & 0.1 & 0 \\ 0 & 0 & 0.1 & 0.833 & 0.067 \\ 0 & 0 & 0 & 0.067 & 0.933 \end{pmatrix} \quad (4.8)$$

$$P_B = \begin{pmatrix} 0.976 & 0.024 & 0 & 0 & 0 \\ 0.017 & 0.933 & 0.05 & 0 & 0 \\ 0 & 0.033 & 0.8 & 0.15 & 0.017 \\ 0 & 0 & 0.15 & 0.733 & 0.17 \\ 0 & 0.017 & 0 & 0.1 & 0.833 \end{pmatrix} \quad (4.9)$$

For example, the first row of  $P_A$  implies that, on average between 2000 and 2005, for a region in group I, the probability of staying in group I after one year is 0.81, the probability of moving to group II is 0.19, and the probability of moving to any other groups (III, IV, or V) is zero. The squared average Markov transition matrix of the first half is calculated as follows.

$$(P_A)^2 = \begin{pmatrix} 0.681 & 0.294 & 0.025 & 0 & 0 \\ 0.206 & 0.581 & 0.2 & 0.013 & 0 \\ 0.0178 & 0.2 & 0.616 & 0.16 & 0.007 \\ 0 & 0.013 & 0.16 & 0.709 & 0.118 \\ 0 & 0 & 0.007 & 0.118 & 0.876 \end{pmatrix} \quad (4.10)$$

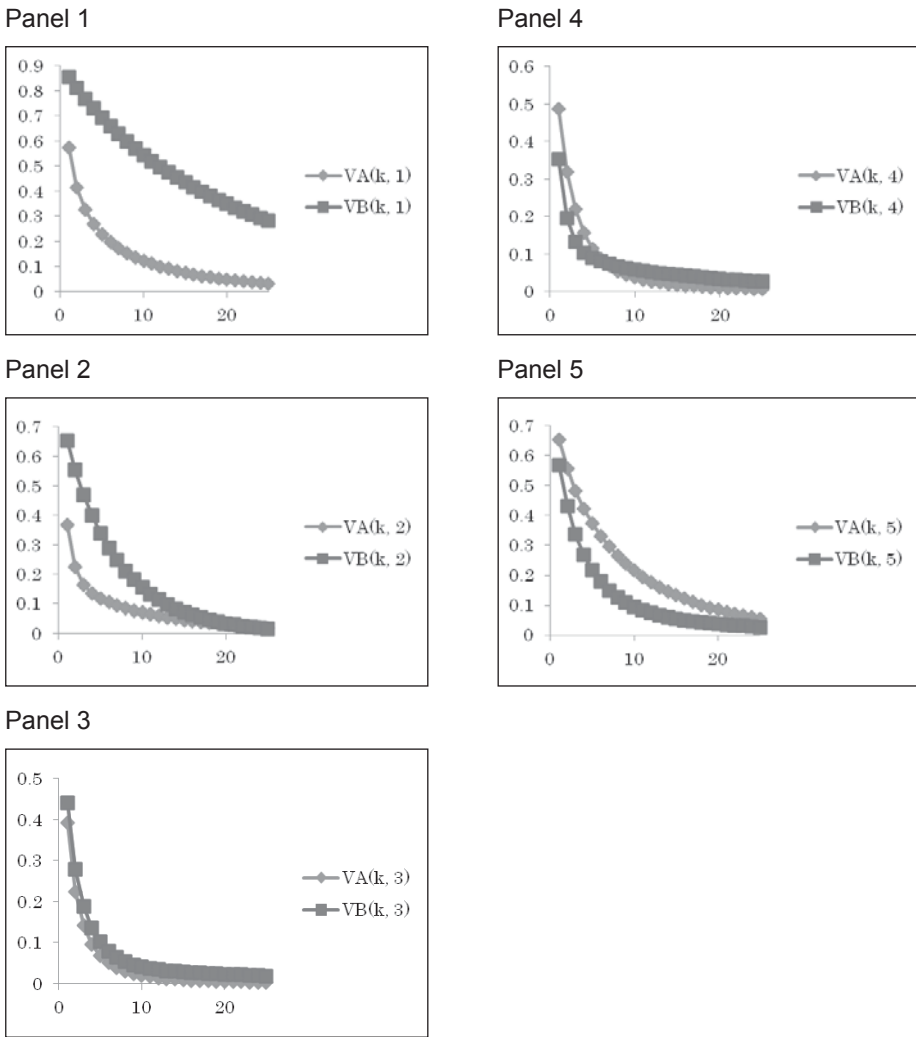
Figure 4.1 The First Row of  $(P_A)^k$  for  $k = 1, 2, 3, 5, 10,$  and  $100$ .



The first row of  $(P_A)^2$  implies that, under the degree of standing order mobility in the first half, for a region in group I, the probability of staying in group I after two years is 0.681, the probability of moving to group II is 0.294, the probability of moving to group III is 0.025, and the probability of moving to group IV or group V is zero. The six panels of figure 4.1 show the first row of  $(P_A)^k$  for  $k = 1, 2, 3, 5, 10,$  and  $100$ . Although a region in group I tends to stay in group I for a short period of time, it may move to the other groups in the long run, and the probability distribution of being in groups I – V seems to converge to the

“uniform” distribution  $\{7/47, 10/47, 10/47, 10/47, 10/47\}$ .

Figure 4.2 The Graphs of  $\{V_A(k, i), V_B(k, i); k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$



The five panels of figure 4.2 show the graphs of  $\{V_A(k, i), V_B(k, i); k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$ . For example, panel 1 shows the graph of the distance  $V_A(k, 1)$  between the first row of average Markov transition matrix  $\{(P_A)^k(1, j); k = 1, 2, 3, \dots, j = 1, 2, 3, 4, 5\}$  and the “uniform” distribution  $\{7/47, 10/47, 10/47, 10/47, 10/47\}$  for the first half  $\{2000, 2001, \dots, 2005\}$  and the graph of  $V_B(k, 1)$  for the second half  $\{2006, 2007, \dots, 2012\}$  such that the horizontal axis measures the power  $\{k = 1, 2, 3, \dots\}$  and the vertical axis measures  $\{V_A(k, 1), V_B(k, 1)\}$ . We may infer the following properties of figure 4.2.

( i ) For the groups of regions with higher user rates (such as group I and group II), the speed of convergence to the “uniform” distribution is faster in the first half than the second half. There is not much difference in the speed of convergence for group III. On the other hand, for the groups of regions with lower user rates (such as group IV and group V), the order seems to be reversed, i.e., the speed of convergence is quicker in the second half than the first half.

(ii) Both in the first half and in the second half, the speed of convergence is slower for the groups of regions with higher user rates and for the groups of regions with lower user rates, and faster for the groups of regions with intermediate user rates.

(iii) In the first half, group V's speed of convergence is the slowest. It would take 7 years to close the distance by less than half, i.e.,  $V_A(1, 5) = 0.6533$  and  $V_A(7, 5) = 0.2961 < V_A(1, 5)/2$ . For the other groups, it would take 3 - 4 years to close the distance by less than half.

(iv) In the second half, group I's speed of convergence is the slowest. It would take 16 years to close the distance by less than half, i.e.,  $V_B(1, 1) = 0.8559$  and  $V_B(16, 1) = 0.4159 < V_B(1, 1)/2$ . For the other groups, it would take 3 - 6 years to close the distance by less than half.

If the problems of public long-term care insurance system that originate from regional differences are more serious in regions with higher user rates, then the 2005 reform does not seem to be effective because the standing order mobility, measured by  $\{V_A(k, i), V_B(k, i); k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$ , did not improve after the reform. The above analyses seem to suggest that the standing order convergence is conditional because there seem to remain persistent regional differences even after the 2005 reform. Each region's user rate may be converging to region-specific steady state, and the standing order of regional user rates may exhibit small variation for the long periods of time. On the other hand, if we are able to remove region-specific factors from the data, then the residual user rates may converge to the same steady state, and the standing order of residual user rates may be more variable. This is what we will try to do in the next section.

## 5. Mobility Analyses of Standing Order based on Residual User Rates

As we saw in the previous section, the standing order (high and low) of regional user rates did not seem to become variable after the 2005 reform which had aimed to alleviate the immobility. As table 3.3 suggests, some regions in group I (consisting of regions with the highest user rates) or group V (consisting of regions with the lowest user rates) do not seem to move to the other groups. Preceding researches suggest that the user rate convergence may be conditional, i.e., each region's user rate may converge to region-specific steady state if each region has different parameter values. Hence, if we are able to remove region-specific elements that cause the differences in regional user rates, the remaining (residual) use rates may converge to a common steady state. Therefore, we regress each region's user rate on the variables that might explain the regional differences, and use the regression residuals to recalculate the speed of convergence to the “uniform” distribution. If the explanatory variables are able to account for the regional differences in user rates, then the speed of convergence of residual user rates will be improved. As a preliminary attempt, we looked at preceding researches and chose the following three explanatory variables; For region (prefecture)  $i = 1, 2, \dots, 47$ , and for year  $t = 2000, 2001, \dots, 2012$ ,  $h_1(i, t)$  is the certification rate which may represent each region's administrative discipline,  $h_2(i, t)$  is the late-stage (75 years or older) old age population rate, and  $h_3(i, t)$  is the ordinary balance rate which may represent the region's fiscal flexibility and robustness. (These data are available from the MHLW and the Ministry of Internal Affairs and Communications.) For each  $t = 2000, 2001, \dots, 2012$ , we estimate the following model.

$$\log_e x(i, t) = a_0 + a_1 \times \log_e h_1(i, t) + a_2 \times \log_e h_2(i, t) + a_3 \times \log_e h_3(i, t) + e(i, t), \quad i = 1, 2, \dots, 47. \quad (5.1)$$

In (5.1),  $x(i, t)$  is the user rate. After obtaining the OLS estimates of regression parameters  $\{a_0, a_1, a_2, a_3\}$ , we use the (exponent of) regression residuals  $\{e(i, t); i = 1, 2, \dots, 47, t = 2000, 2001, \dots, 2012\}$  to calculate the speed of convergence before and after the 2005 reform as we had done in the previous section. Table 5.1 summarizes the regression results. The fitting of the statistical model (5.1) to the data is not so good. Although the three variables  $\{h_1, h_2, h_3\}$  together explain 70 - 80% of the variation in the user rate  $x$ , the only significant variable is the certification rate  $h_1$ . The ordinary balance rate  $h_2$  is marginally significant. The late-stage old age population rate  $h_3$  is insignificant.

Table 5.1 OLS Estimates of Equation (5.1)

	Intercept	h1(i, t)	h2(i, t)	h3(i, t)	Adjusted R2
2000	2.975	0.875	0.129	0.077	0.827
(t Value)	11.613	11.891	1.898	2.013	
2001	2.974	0.881	0.065	0.066	0.803
(t Value)	12.038	11.744	0.981	1.788	
2002	2.892	0.858	0.034	0.057	0.795
(t Value)	12.531	11.987	0.524	1.612	
2003	3.036	0.862	0.071	0.068	0.776
(t Value)	12.041	11.560	0.919	1.690	
2004	3.088	0.919	0.030	0.069	0.791
(t Value)	14.198	12.282	0.451	2.021	
2005	3.167	0.956	0.028	0.081	0.784
(t Value)	14.792	12.042	0.421	2.327	
	Intercept	h1(i, t)	h2(i, t)	h3(i, t)	Adjusted R2
2006	3.051	0.934	0.006	0.065	0.755
(t Value)	14.101	10.747	0.094	1.823	
2007	2.792	1.011	-0.148	0.023	0.452
(t Value)	7.005	5.900	-1.118	0.358	
2008	2.984	0.948	-0.031	0.053	0.718
(t Value)	13.392	9.423	-0.397	1.504	
2009	3.038	0.967	-0.031	0.060	0.730
(t Value)	13.582	9.595	-0.383	1.652	
2010	3.039	0.954	-0.029	0.062	0.734
(t Value)	13.461	9.820	-0.363	1.653	
2011	3.078	0.988	-0.046	0.068	0.747
(t Value)	13.158	10.242	-0.548	1.711	
2012	3.028	0.985	-0.066	0.055	0.743
(t Value)	12.950	10.085	-0.764	1.405	

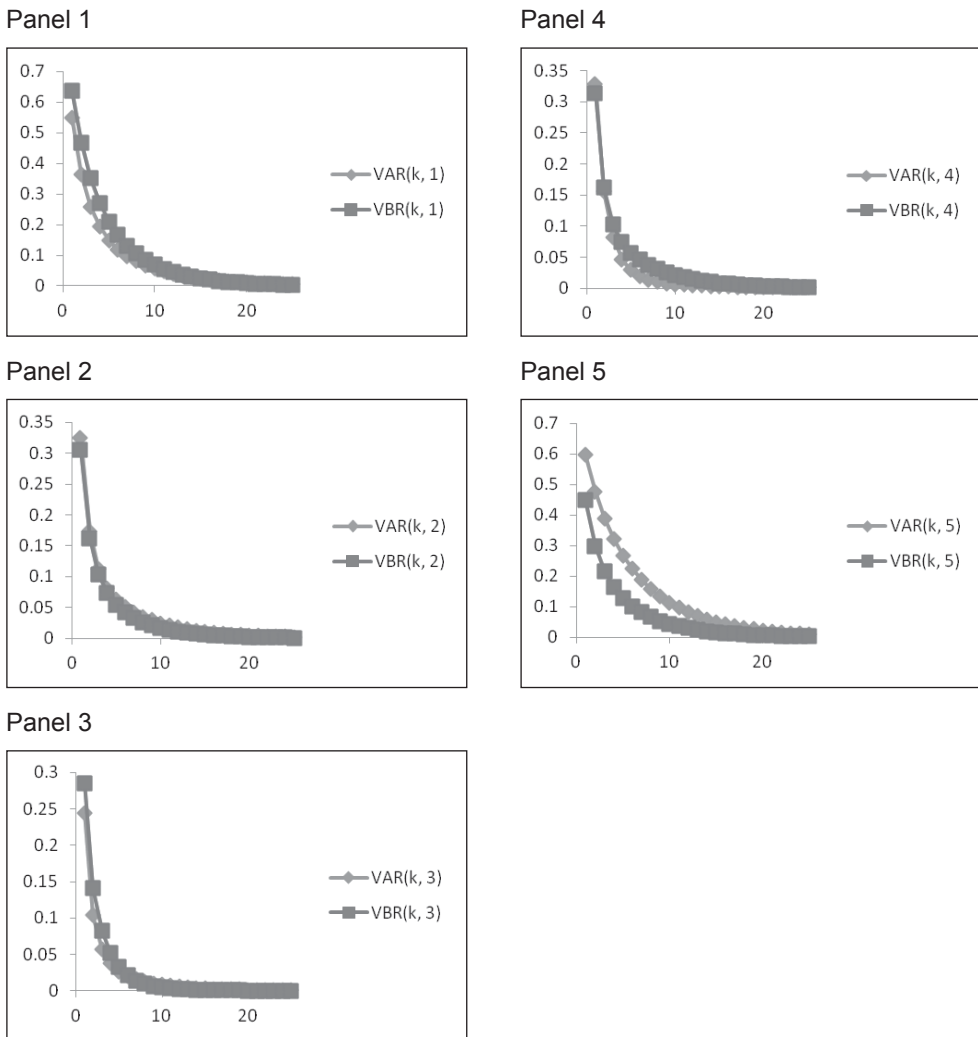
$h_1(i, t)$ : certification rate

$h_2(i, t)$ : late-stage (75 years or older) old age population rate

$h_3(i, t)$ : ordinary balance rate

We used the regression residuals to calculate average Markov transition matrixes, denoted as  $P_{AR}$  for the first half {2000, 2001, ..., 2005} and  $P_{BR}$  for the second half {2006, 2007, ..., 2012}. Then we used  $\{(P_{AR})^k, (P_{BR})^k; k = 1, 2, \dots\}$  to calculate the distances, denoted as  $\{V_{AR}(k, i), V_{BR}(k, i); k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$ , from the “uniform” distribution  $\{7/47, 10/47, 10/47, 10/47, 10/47\}$  for the first half and the second half. The five panels of figure 5.1 show the graphs of  $\{V_{AR}(k, i), V_{BR}(k, i); k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$ . Even after adjusted for the region-specific factors, like  $\{V_A(k, i), V_B(k, i)\}$  for the unadjusted user rates shown in figure 4.2, the speed of convergence of group I  $V_{AR}(k, i)$  is faster in the first half than the second half  $V_{BR}(k, i)$ , while the order is reversed for group V .

Figure 5.1 The Graphs of  $\{V_{AR}(k, i), V_{BR}(k, i); k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$





The five panels of figure 5.2 plot and compare the adjusted distance for the first half  $V_{AR}(k, i)$  and the unadjusted distance  $V_A(k, i)$  for the first half. Similarly, the five panels of figure 5.3 plot and compare the adjusted distance for the second half  $V_{BR}(k, i)$  and the unadjusted distance  $V_B(k, i)$  for the second half. These figures show that for the first half and the second half, and for all the 5 groups, the speed of convergence is faster after adjusted for the region-specific factors. This implies that the convergence might have been conditional, i.e., each region's user rate, if unadjusted for region-specific factors, is converging to region-specific steady state user rate.

Figure 5.2 The Graphs of  $\{V_A(k, i), V_{AR}(k, i); k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$

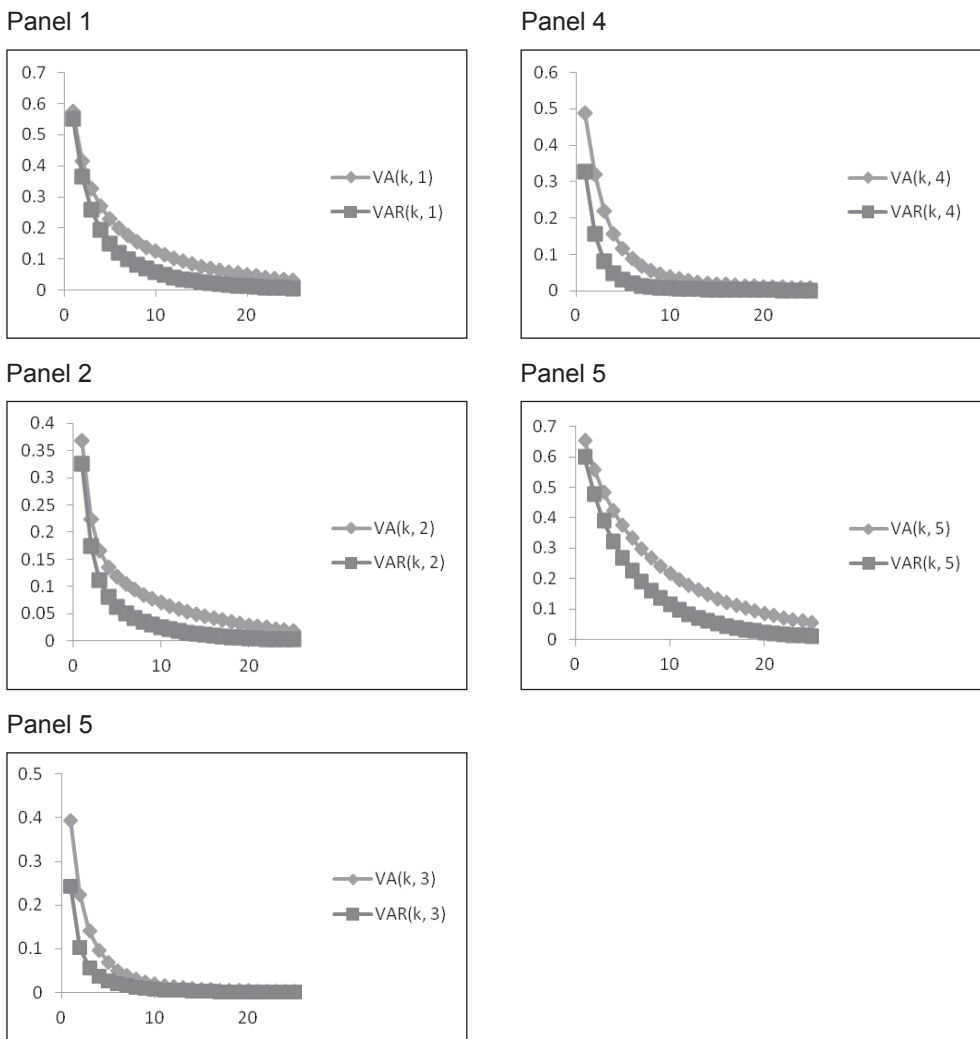
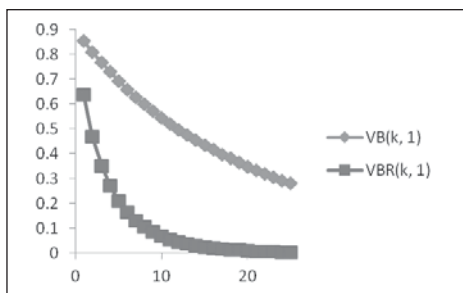
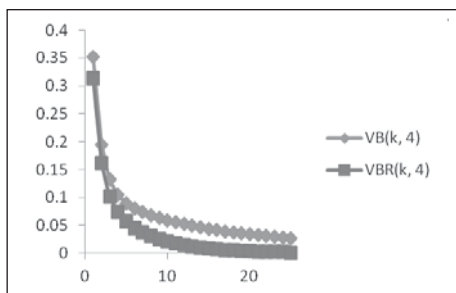


Figure 5.3 The Graphs of  $\{V_B(k, i), V_{BR}(k, i); k = 1, 2, 3, \dots, i = 1, 2, 3, 4, 5\}$

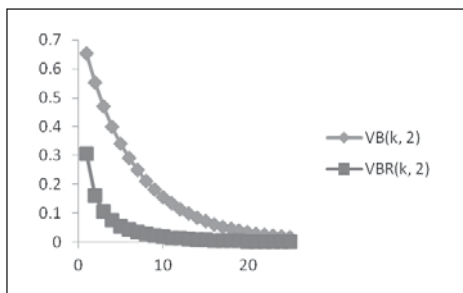
Panel 1



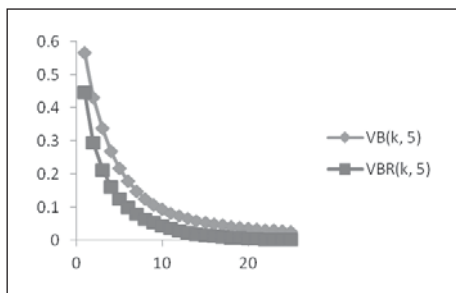
Panel 4



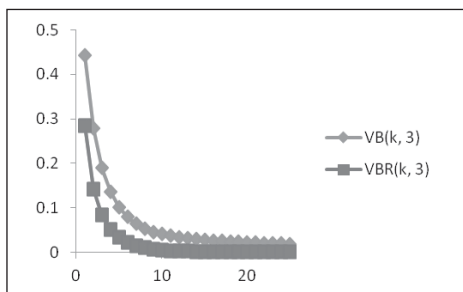
Panel 2



Panel 5



Panel 3



It turned out as well, however, that the standing order of regional user rates, even after being adjusted for region-specific factors, is not quite variable yet. Table 5.2 shows the 5 regions with the highest residual user rates and the 5 regions with the lowest residual user rates between 2000 and 2012. The table shows that some regions still hardly change their positions in the standing order. For example, Hokkaido stays the 47<sup>th</sup> for all the sample years but 2007, while Nagano stays the first for all but two years. These observations suggest that there are factors other than the ones we chose (the certification rate, the late-stage old age population rate, and the ordinary balance rate) that cause the regional differences in user rates.

Table 5.2 Regional User Rates (Regression Residuals): The Highest 5 Regions and the Lowest 5 Regions

STANDING	2000	2001	2002	2003	2004	2005
1	Shiga	Nagano	Nagano	Nagano	Nagano	Nagano
2	Aomori	Shiga	Shiga	Kyoto	Wakayama	Wakayama
3	Nagano	Aomori	Kyoto	Shiga	Kyoto	Shiga
4	Gifu	Gifu	Yamagata	Wakayama	Shiga	Kyoto
5	Kanagawa	Yamagata	Niigata	Niigata	Yamagata	Niigata
43	Fukuoka	Fukuoka	Osaka	Toyama	Mie	Ishikawa
44	Kochi	Yamaguchi	Akita	Yamaguchi	Yamaguchi	Yamaguchi
45	Yamaguchi	Kochi	Yamaguchi	Osaka	Akita	Akita
46	Akita	Akita	Kochi	Kochi	Kochi	Kochi
47	Hokkaido	Hokkaido	Hokkaido	Hokkaido	Hokkaido	Hokkaido

STANDING	2006	2007	2008	2009	2010	2011	2012
1	Wakayama	Nagano	Nagano	Nagano	Nagano	Nagano	Nagano
2	Nagano	Wakayama	Wakayama	Wakayama	Shiga	Shiga	Aomori
3	Shiga	Yamagata	Shiga	Shiga	Aomori	Aomori	Shiga
4	Kyoto	Shiga	Aomori	Aomori	Wakayama	Yamanashi	Wakayama
5	Yamagata	Aomori	Kyoto	Yamanashi	Yamanashi	Wakayama	Yamanashi
43	Ishikawa	Nagasaki	Okayama	Kagoshima	Kagoshima	Kagoshima	Kagoshima
44	Mie	Okinawa	Ibaraki	Ibaraki	Ibaraki	Ibaraki	Yamaguchi
45	Yamaguchi	Hokkaido	Yamaguchi	Yamaguchi	Yamaguchi	Yamaguchi	Ibaraki
46	Kochi	Kochi	Kochi	Kochi	Kochi	Kochi	Kochi
47	Hokkaido	Niigata	Hokkaido	Hokkaido	Hokkaido	Hokkaido	Hokkaido

## 6. Conclusion

In this research, we analyzed the dynamic properties of the regional differences in user rates defined as the ratio of long-term care service users relative to the primary insured individuals (65 years or older). This is a preliminary research. The followings are some of the issues yet to be addressed.

( i ) Find factors that account for the differences in regional figures

( ii ) In this research, we analyzed the regional differences among prefectures. The difference, however, may be wider and more prominent among less aggregated levels such as villages, towns, and cities. For example, in each prefecture, the behavior of covered individuals and insurers (municipalities) at countryside may be very different from that of urbane area. Therefore, it might be desirable to employ detailed case studies to supplement the approach employed in this research.

( iii ) The theoretical model of section 2 does not have detailed structure of the market for long-term care services. For a better understanding of the market, it is desirable to enrich the model by incorporating such elements as demand, supply, prices, taxes, and subsidies.

## Appendix. Data Sources and Its Properties.

For the analyses in this research, we used the data provided by the Japan Ministry of Health, Labor, and Welfare. [The Reports on Long-term Care Insurance System: Annual Reports, 2000 - 2012 Fiscal Years (URL <http://www.mhlw.go.jp/topics/kaigo/joukyou.html>)] There are some cautions on using the data;

( i ) The public long-term care insurance system started on April 2000. Therefore, the data for 2000 fiscal year consists of 11 months, from April 2000 to February 2001. The data for each fiscal year between 2001 and 2012 consists of 12 months, from March of the year to the February of the next year.

( ii ) In accordance with the 2005 reform, community-based services started on April 2006. The total number of long-term care services in each fiscal year between 2000 and 2005 and March 2006 is the sum of in-home services and facility services. On the other hand, the total number of services after April 2006 includes community-based services in addition to the formerly provided services.

( iii ) We analyzed the data of primary insured individuals (65 years or older). The data of secondary insured individuals (40 - 64 years old) are excluded.

( iv ) Because each primary insured individual may use in-home services, facility services, and community-based services many times in a year, the user rate, defined as the total number of services used by primary insured individuals divided by the number of primary insured individuals, may exceeds one. In the theoretical model of section 3, the user rate  $x_t \equiv X_t/L_t$  is defined as the ratio of the number of insured individuals who use services  $X_t$  to the number of insured individuals  $L_t$ . An insured individual is included in  $X_t$  if she uses at least one service.  $X_t$  does not reflect the number of services each insured individual uses. This implies  $0 \leq x_t \leq 1$  in the theoretical model. Therefore, we implicitly assume that if the theoretical model is true so that the user rate  $x_t$  converges to the steady state  $x^*$ , the same force also works on the user rate calculated from the data in the manner stated above.

Because of the discontinuity, we looked at two series. Series [ALL] includes all the services, while series [EXC] excludes the community-based services from the second half data. Table A1 reports the basic statistics of regional user rates [ALL]; mean, annual rate of change, variance, coefficient of variation, maximum value, minimum value, and max?min ratio. Table A1 also reports the basic statistics of regional user rates [EXC].

**Table A1 Regional User Rates with and without Community-Based Services**

	Mean [ALL]	GrowthRate [ALL]	Variance [ALL]	Coeff.Var [ALL]	Max [ALL]	Min [ALL]	Max/Min [ALL]
2000	1.9812		0.0809	0.0408	2.7487	1.4134	1.9448
2001	2.5566	0.2904	0.1103	0.0431	3.3282	1.8398	1.8090
2002	2.9556	0.1561	0.1301	0.0440	3.7131	2.1468	1.7296
2003	3.3046	0.1181	0.1519	0.0460	4.0299	2.4232	1.6630
2004	3.5668	0.0794	0.1706	0.0478	4.4533	2.6575	1.6757
2005	3.7049	0.0387	0.1839	0.0496	4.7039	2.8077	1.6754
2006	3.6365	-0.0185	0.1647	0.0453	4.6696	2.8181	1.6570
2007	3.5820	-0.0150	0.2127	0.0594	4.6814	1.9558	2.3936
2008	3.6935	0.0311	0.1674	0.0453	4.8177	2.8299	1.7024
2009	3.8090	0.0313	0.1783	0.0468	4.9431	2.8929	1.7087
2010	4.0018	0.0506	0.1831	0.0457	4.9355	3.0319	1.6279
2011	4.1344	0.0331	0.1979	0.0479	5.1233	3.1104	1.6472
2012	4.2280	0.0226	0.1991	0.0471	5.2352	3.1706	1.6512

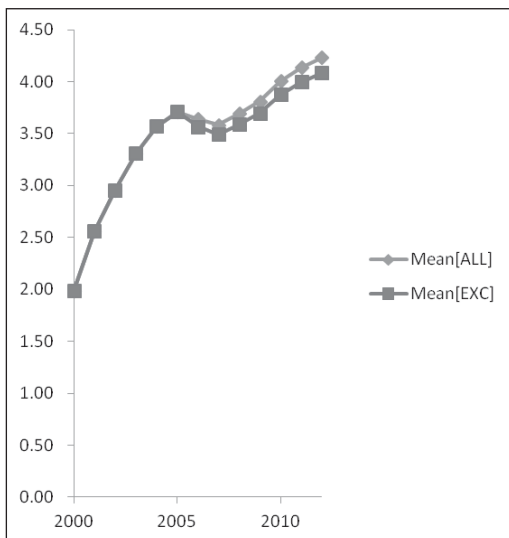
	Mean [EXC]	GrowthRate [EXC]	Variance [EXC]	Coeff.Var [EXC]	Max [EXC]	Min [EXC]	Max/Min [EXC]
2000	1.9812		0.0809	0.0408	2.7487	1.4134	1.9448
2001	2.5566	0.2904	0.1103	0.0431	3.3282	1.8398	1.8090
2002	2.9556	0.1561	0.1301	0.0440	3.7131	2.1468	1.7296
2003	3.3046	0.1181	0.1519	0.0460	4.0299	2.4232	1.6630
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2007	3.5820	-0.0150	0.2127	0.0594	4.6814	1.9558	2.3936
2008	3.6935	0.0311	0.1674	0.0453	4.8177	2.8299	1.7024
2009	3.8090	0.0313	0.1783	0.0468	4.9431	2.8929	1.7087
2010	4.0018	0.0506	0.1831	0.0457	4.9355	3.0319	1.6279
2011	4.1344	0.0331	0.1979	0.0479	5.1233	3.1104	1.6472
2012	4.2280	0.0226	0.1991	0.0471	5.2352	3.1706	1.6512

[ALL] Includes Community-Based Services. [EXC] Community-Based Services Excluded.  
 Data Source: Japan Ministry of Health, Labor, and Welfare

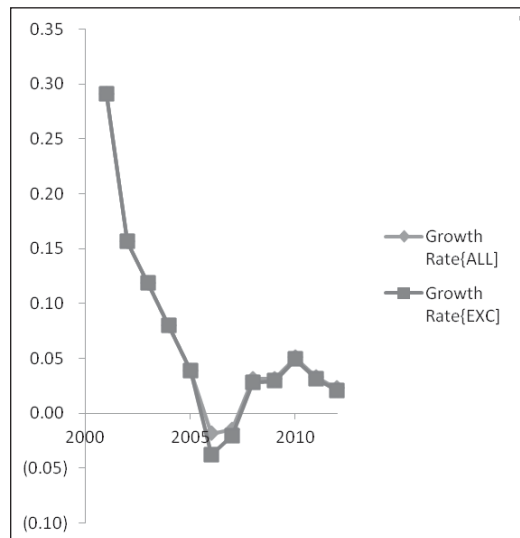
Panel 1 of figure A1 depicts the graph of average user rate [ALL] and the graph of [EXC]. Because of the introduction of community-based services in the second half, the average user rate [ALL] is higher than [EXC] in the second half. Despite the inclusion of community-based services, these graphs show the similar movements. Between 2000 and 2005, the average user rate increased, but at diminishing growth rate. After the temporary decline in 2006 and 2007, the average user rate began to increase again. The speed of the growth diminished for the last two years, 2011 and 2012. We can reconfirm these properties in panel 2 of figure A1 which depicts the growth rate of the user rate [ALL] and that of [EXC]. Since both user rates [ALL] and [EXC] show similar movements, in this research we focus on the analyses of user rate [ALL] that includes the community-based services in the second half.

Figure A1 Regional User Rates with and without Community-Based Services

Panel A User Rates



Panel B Growth Rates of User Rates



Data Source: Japan Ministry of Health, Labor, and Welfare

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## Data and Statistics Sources

Japan Ministry of Health, Labor, and Welfare

Japan Ministry of Internal Affairs and Communications Statistics Bureau

OECD Health Statistics 2015