Estimation Results

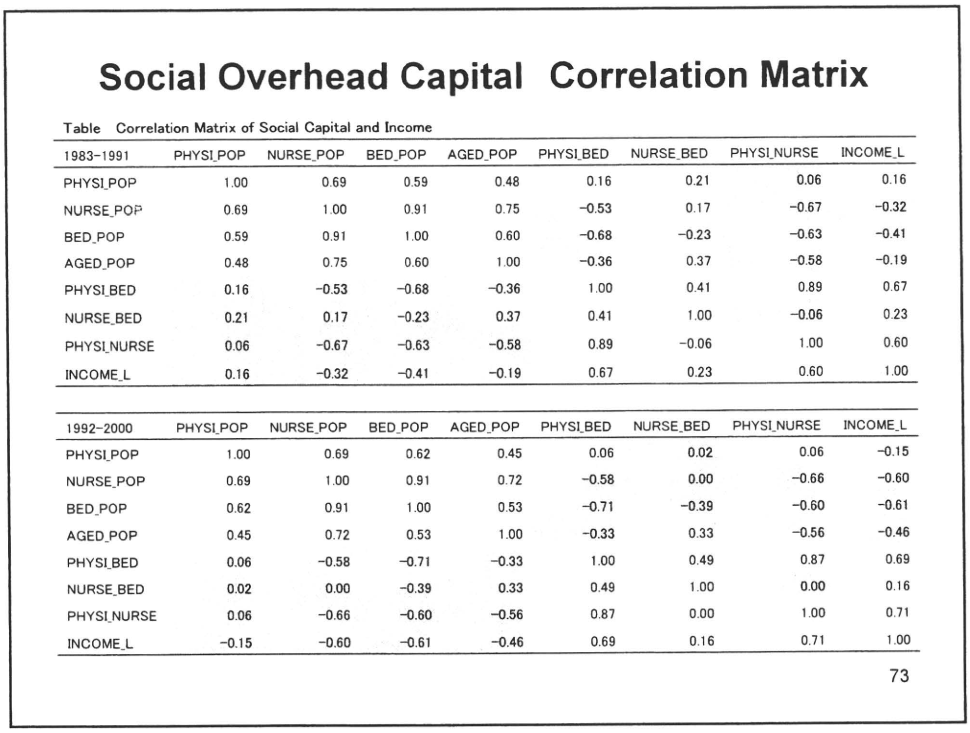
1. Too high speed of convergence
   Coefficients of the lagged dependent variables 0.40-0.50
   With the average "condtions", the speed of convergence exceeds 0.25 per year (overestimation)

2. C/D (cost per day) is negatively related with D/E (days per event) or with E/N(events per population)

3. The larger GDP increases C/D, E/N not D/E
   Beds per population increases D/E
   Phsicians per population has no effects
   Nurses per population increases C/D
   Aged home capacity decreased D/E while increases E/N

Table 1 Summary Statistics

	1983-1991		1992-2000	
	mean	s.e.	mean	s.e.
Gen Inpatient Cost/Day	9.586	0.085	9.764	0.116
Gen Outpatient Cost/Day	8.481	0.142	8.746	0.097
Aged Inpatient Cost/Day	9.593	0.125	9.805	0.134
Aged Outpatient Cost/Day	8.615	0.161	8.831	0.125
Gen. Inpatient Days/Person	1.391	0.285	1.577	0.272
Gen. Outpatient Days/Person	2.511	0.177	2.631	0.155
Aged_Inpatient Days/Person	3.023	0.339	2.908	0.299
Aged Outpatient Days/Person	3.693	0.207	3.717	0.167
PHYSICIANS/POP	1.542	0.303	1.847	0.338
NURSES/POP	5.943	1.580	7.671	1.941
BEDS/POP	14.465	4.065	14.721	4.168
AGED/POP	0.124	0.023	0.169	0.031
PHYSICIANS/BED	0.111	0.025	0.131	0.029
NURSES/BED	0.414	0.044	0.527	0.058
PHYSICIANS/NURSE	0.269	0.056	0.249	0.048

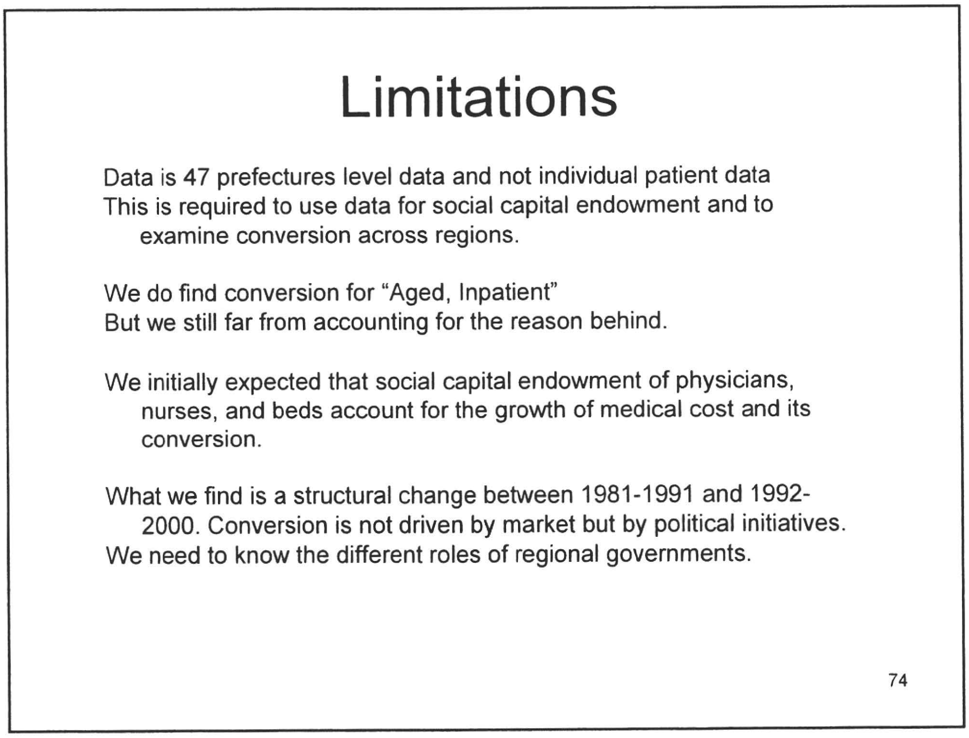


Social Overhead Capital Correlation Matrix

Table Correlation Matrix of Social Capital and Income

1983-1991	PHYSI_POP	NURSE_POP	BED_POP	AGED_POP	PHYSI_BED	NURSE_BED	PHYSI_NURSE	INCOME_L
PHYSI_POP	1.00	0.69	0.59	0.48	0.16	0.21	0.06	0.16
NURSE_POP	0.69	1.00	0.91	0.75	−0.53	0.17	−0.67	−0.32
BED_POP	0.59	0.91	1.00	0.60	−0.68	−0.23	−0.63	−0.41
AGED_POP	0.48	0.75	0.60	1.00	−0.36	0.37	−0.58	−0.19
PHYSI_BED	0.16	−0.53	−0.68	−0.36	1.00	0.41	0.89	0.67
NURSE_BED	0.21	0.17	−0.23	0.37	0.41	1.00	−0.06	0.23
PHYSI_NURSE	0.06	−0.67	−0.63	−0.58	0.89	−0.06	1.00	0.60
INCOME_L	0.16	−0.32	−0.41	−0.19	0.67	0.23	0.60	1.00

1992-2000	PHYSI_POP	NURSE_POP	BED_POP	AGED_POP	PHYSI_BED	NURSE_BED	PHYSI_NURSE	INCOME_L
PHYSI_POP	1.00	0.69	0.62	0.45	0.06	0.02	0.06	−0.15
NURSE_POP	0.69	1.00	0.91	0.72	−0.58	0.00	−0.66	−0.60
BED_POP	0.62	0.91	1.00	0.53	−0.71	−0.39	−0.60	−0.61
AGED_POP	0.45	0.72	0.53	1.00	−0.33	0.33	−0.56	−0.46
PHYSI_BED	0.06	−0.58	−0.71	−0.33	1.00	0.49	0.87	0.69
NURSE_BED	0.02	0.00	−0.39	0.33	0.49	1.00	0.00	0.16
PHYSI_NURSE	0.06	−0.66	−0.60	−0.56	0.87	0.00	1.00	0.71
INCOME_L	−0.15	−0.60	−0.61	−0.46	0.69	0.16	0.71	1.00



Limitations

Data is 47 prefectures level data and not individual patient data
This is required to use data for social capital endowment and to examine conversion across regions.

We do find conversion for “Aged, Inpatient”
But we still far from accounting for the reason behind.

We initially expected that social capital endowment of physicians, nurses, and beds account for the growth of medical cost and its conversion.

What we find is a structural change between 1981-1991 and 1992-2000. Conversion is not driven by market but by political initiatives.
We need to know the different roles of regional governments.

Tentative Results

A1: Increase in medical cost is due to “population growth” in Aged Inpatient and outpatient

and “cost per day” while “days per person” has declined

A2: Extremely large estimates of convergence speed, 25 percent a year

A3: Estimation and decomposistion have different results.

Limitations

Estimations of the condtional convergence tend to overestimate convergence speed

Decomposition and estimation have the different results.

Social overhead capital are related to medical cost in more complicated manner

参考資料

本研究では下記論文のモデルを修正して，新しいデータに応用する。参考資料として添付する。

Geographical Variation and Convergence of Medical Services and Social Capital
(2009)
ANEGAWA, Tomofumi
Keio University, Graduate School of Business Administration

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Summary

Among developed countries, Japan has achieved one of the highest longevity of the people with lower ratio of medical expense to GDP. This is assisted by the nation-wide health insurance introduced in 1961. Although regional differences are small in longevity, there are significant geographical variances for medical resources, services, and cost. The government has long adopted cost containment policy by improving efficiency of the inefficient regions. Empirical questions should be raised on the degrees and sources of the variance and convergence speed of medical cost across regions. Impact of policy such as the introduction of the Long-term Care Insurance in 2000 should be evaluated. Many empirical researches have been conducted on these issues as surveyed in IHEP (2007). There are, however, common shortcomings with research methods. First, most studies rely on cross-section data with only short time periods. Because regional specific effects persist over time and the convergence takes time, one needs to utilize pooled time-series and cross-section data. Second, most studies investigate the effects of explanatory variables in ad hoc manner without concrete theoretical framework. Accordingly they fail to reach the conclusion on causal relationship in a meaningful sense.

This study uses medical cost data of the "Municipal Health Insurance (*Kokumin Kenkohoken*)" and health related data of 47 prefectures in 1981-2005 to pool time-series and cross-section data. This allows analysis on the variance and sources of the "Hospitalization (Inpatient)", "Outpatient", and "Dental" services for the "general" and "aged" population. Using an expression of the "cost per capita (C/N)" as the product of "cost per day (C/D)", "days per event (D/E)" and "events per population (E/N)", the variance of C/N is analyzed. The large regional variance of the aged hospitalization had declined sharply in the 1990s, the source of which was mostly explained by the decline of events per population. Next this study estimates the convergence speed of the variance of (C/N), (C/D), (D/E), and (E/N) separately.

We find the convergence of the aged hospitalization and outpatient services in a "conditional sense" in which each region approaches its own stationary level within 15 years. Convergence was associated with the E/N for the hospitalization and D/E for the outpatient. Also there are negative relationship between the convergence of (C/D) and that of (D/E), which indicates regions with higher (D/E) tend to have less (C/D) (quicker convergence) and vice versa. The increase in GDP per capita had slowed the convergence speed in C/D. The increase in doctors (physicians) per population and the nurses per population slowed the higher speed of convergence of C/D. The capacity of the "aged home" per population has increased the convergence speed of D/E while they decreased the speed of E/N. Revisions of the official medical prices, raise of the co-payment rates, and the introduction of the Health Insurance for the Aged in 1983, Long-term Care Insurance in 2000 had significant impact on the pattern of convergence. Although these results have important implications for the variance and convergence, they depend on these variables in a complicated manner. Also region-specific effects are large for some regions. We cannot present a simple policy rule to govern the variance and convergence of medical cost.

Key words: medical, health, geography, convergence JEL: J14, J18, O49

1. Introduction

Although Japan has achieved high longevity across regions, there are significant differences in health capital, medical services, and medical cost. Geographical variation of medical sector within the country is widely known and there are numerous studies on geographical variations (Cutler David and Louise Sheiner (1999)[1], Wennberg, John E. Elliott S. Fisher, and Jonathan S. Skinner (2002)[2]). Among various measures for medical services, "per capita medical cost (C/N)" is one of the most widely used measures for evaluating performance of medical sector. Because of large geographical variance of per capita medical cost in Japan, many empirical studies have addressed a question what causes the variances. There are two types of empirical studies in terms of data type, one is to use individual data on medical claims, and the other is to use aggregated data for each region. The latter type studies mostly use 47 "prefecture" data (IHEP, 2007)[3]. These studies, however, are in principle cross-section studies with short time periods. Accordingly, they fail to address questions like whether there is convergence of the geographical differences, what causes the convergence, and what is the speed of convergence.

In growth theory, geographical variation across regions has achieved attentions and econometrics method to utilize panel data consisting of both time-series and cross-section data (Barro and Sala-i-Martin,1995).[4] They focus on geographical convergence of GDP in the long-run. In response, there are studies on Japanese variation of GDP across regions by using panel data (e.g. Shioji, 2000)[5]. This study analyzes the geographical variances using panel data based on empirical method found in convergence in growth theory.

Related to geographical convergence of GDP, there are studies to address what constitutes the variances.
We also analyze the sources of convergence by decomposing "per capita cost (C/N)" into "cost per day (C/D), "days per event(D/E), and "per capita events (events per person) (E/N)" . Because these component variables move differently over time periods, we can detect what is the sources of convergence of per capita cost.

2. Research Method

Medical cost C_{htsijk} is defined for the h-th prefecture, t-th fiscal year, s-th type health plan, i-th medical service, j-th individual, treated at m-th hospital/clinics. Instead of using medical claim data, we use aggregated data for h, t, s("General" and "Aged" of the Municipal Health Insurance) , i-th services ("Hospitalization", "Outpatient", and "Dental "services).

$$C_{htsi} = \sum_{j\in J} \sum_{m\in K} C_{htsijm} \qquad (1)$$

We use "City-Town-Village Municipal National Health Insurance Plan: (*Shi-Cho-Son Kokumin Kenkohoken*)" as data source which covers people residing in its region and are not covered by other public health plans or public assistance. Japanese national health insurance plan consists of two types of the health insurance plan, one is the profession based insurance, and the other is residence based insurance. The latter is the municipal insurance administered by city, town, or village. The Municipal Health Insurance provides medical insurance with the "general insured" who reside in that city, town, or village, except those who are insured by other public health insurance plans or those who are provided with health service

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[1] "The Geography and Medicare" Federal Reserve Board Working paper, 1999.

[2] "Geography and the Debate Over Medicare Reform,", Health Affairs, Web Exclusive reappeared in *Health Affairs* "Variations Revisited" in 2004. Survey is found in Health Affairs, 2004.

[3] IHEP, "*Kuni Oyobi Todoufuken Reberu de no Iryohi-no Ketteiyouin Bunseki*", Report. It lists 79 empirical studies, most of which use either prefecture or city-town-village as sample units of region.

[4] Barro and Sala-i-Martin, *Economic Growth,* McGraw Hill, 1995.

[5] Etsuro Shioji, "Ch.8, Nihon no Chi-iki Syotoku no Syusoku to Syakai Shihon", in Hiroshi Yoshikawa and Masayuki Otaki ed. *Jyunkan to Seicyo no Macro Keizaigaku,* 2000. University of Tokyo Press.

by public assistance. Prior to 2008, the Municipal Health Insurance provides health insurance with the retired younger than 65 years old and his/her dependents. This study includes the "retired" in the "general". The municipal also provides the aged people older than 70 years old with health insurance service through the "Health Insurance Plan for the Aged[6]".

Thus the insured people are defined as:

N_{hts} : the average number of the insured in s-type health plan in h-th prefecture of t-th fiscal year.

$$N_{hts} = \sum_s N_{hts} = N_{htg} + N_{hta} \tag{2}$$

where "g" stands for "general" and "a" for "aged".

E_{htsi} : the number of events when the insured receives medical services.

Because hospital/clinics present the national health insurance plan with the medical data in every month, the number of events is counted for every month. When the same medical service is provided in two consecutive months, they are counted as two separate events.

D_{htsi} , aggregate days of h-th prefecture in t-th year of the s-th health insurance.

The following measures are constructed using the above data.

Days per event (in a month) $d^E_{htsi} = D_{htsi} / E_{htsi}$ (3)

Events per population $e^N_{htsi} = E_{htsi} / N_{hts}$ (4)

Days per person $d^N_{htsi} = D_{htsi} / N_{hts}$ (5)

Cost per capita in real terms (1000 Yen) $c^N_{htsi} = C_{htsi} / N_{hts}$ (6)

Cost per capita is decomposed into (7) and (8).

$$c^N_{htsi} = \frac{C_{htsi}}{N_{hts}} = \frac{C_{htsi}}{D_{htsi}} \cdot \frac{D_{htsi}}{E_{htsi}} \frac{E_{htsi}}{N_{hts}} = c^D_{htsi} d^E_{htsi} e^N_{htsi} \tag{7}$$

$$c^N_{htsi} = \frac{C_{htsi}}{N_{hts}} = \frac{C_{htsi}}{D_{htsi}} \cdot \frac{D_{htsi}}{N_{hts}} = c^D_{htsi} d^N_{htsi} \tag{8}$$

Cost per event $c^E_{htsi} = C_{htsi} / E_{htsi}$ (9)

Cost per day $c^D_{htsi} = C_{htsi} / D_{htsi}$ (10)

$$C_{hts} = \sum_s \sum_i C_{htsi} = \sum_s \sum_i (C_{htsi} / N_{hts}) N_{hts} = \sum_s \sum_i c^N_{htsi} N_{hts} \tag{11}$$

By taking the difference between the period and previous period, the following equation represents the change in medical cost.

$$\Delta C_{hts} = \sum_s \sum_i \Delta C_{htsi} = \sum_s \sum_i \Delta((C_{htsi} / N_{hts}) N_{hts}) = \sum_s \sum_i (\Delta c^N_{htsi} \cdot N_{hts} + c^N_{htsi} \Delta N_{hts}) \tag{12}$$

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[6] "*Rojin Kenko Hoken Seido*".

Equation (6) $c^N_{htsi} = c^D_{htsi} d^E_{htsi} e^N_{htsi}$ is expressed in equation (13).

$$\Delta c^N_{htsi} = \Delta c^D_{htsi} \cdot d^E_{htsi} \cdot e^N_{htsi} + c^D_{htsi} \cdot \Delta d^E_{htsi} \cdot e^N_{htsi} + c^D_{htsi} \cdot d^E_{htsi} \cdot \Delta e^N_{htsi} \tag{13}$$

$$\frac{\Delta C_{ht}}{C_{ht}} = \sum_s \sum_i \left\{ \left(\frac{\Delta c^D_{htsi}}{c^D_{htsi}} + \frac{\Delta d^E_{htsi}}{d^E_{htsi}} + \frac{\Delta e^N_{htsi}}{e^N_{htsi}} + \frac{\Delta N_{hts}}{N_{hts}} \right) \cdot \frac{C_{htsi}}{C_{hts}} \right\} \tag{14}$$

The change in medical cost is expressed in terms of the growth rate of each variable.

Growth rate of cost $g(C_{ht}) = \dfrac{\Delta C_{ht}}{C_{ht}}$,

Growth rate of cost per day $g(c^D_{htsi}) = \dfrac{\Delta c^D_{htsi}}{c^D_{htsi}}$,

Growth rate of days per event $g(d^E_{htsi}) = \dfrac{\Delta d^E_{htsi}}{d^E_{htsi}}$,

Growth rate of events per population $g(e^N_{htsi}) = \dfrac{\Delta e^N_{htsi}}{e^N_{htsi}}$,

Growth rate of the insured in s-type group $g(N_{hts}) = \dfrac{\Delta N_{hts}}{N_{hts}}$,

Weight of i-th medical service in total medical cost. $w_{htsi} = \dfrac{C_{htsi}}{C_{hts}}$,

Growth of medical cost is expressed in a following equation.

$$g(C_{ht}) = \sum_s \sum_i \left\{ \left(g(c^D_{htsi}) + g(d^E_{htsi}) + g(e^N_{htsi}) + g(N_{hts}) \right) \cdot w_{htsi} \right\}$$

$$= \sum_s \sum_i \left\{ g(c^D_{htsi}) w_{htsi} + g(d^E_{htsi}) w_{htsi} + g(e^N_{htsi}) w_{htsi} + g(N_{hts}) w_{htsi} \right\} \tag{15}$$

The growth of medical cost is the weighted sum of the cost per day, days per event, events per capita, the growth rate of the s-type insured. In the same fashion, we have the following equation.

$$\frac{\Delta C_{ht}}{C_{ht}} = \sum_s \sum_i \left\{ \left(\frac{\Delta c^D_{htsi}}{c^D_{htsi}} + \frac{\Delta d^N_{htsi}}{d^N_{htsi}} + \frac{\Delta N_{hts}}{N_{hts}} \right) \cdot \frac{C_{htsi}}{C_{hts}} \right\} \tag{16}$$

$$g(C_{ht}) = \sum_s \sum_i \left\{ \left(g(c^D_{htsi}) + g(d^N_{htsi}) + g(N_{hts}) \right) \cdot w_{htsi} \right\} \tag{17}$$

$$g(C_{ht}) = \sum_s \sum_i \left\{ g(c^D_{htsi}) w_{htsi} + g(d^N_{htsi}) w_{htsi} + g(N_{hts}) w_{htsi} \right\} \tag{18}$$

$$g(C_{ht}) = \sum_s \sum_i \left\{ g(c^D_{htsi}) w_{htsi} + g(d^N_{htsi}) w_{htsi} + g(N_{hts}) w_{htsi} \right\} \tag{19}$$

The above equation is interpreted as contribution of each factor to growth.

$$\sum_s \sum_i \left\{ g(c^D_{htsi}) w_{htsi} \right\} \quad \text{Contribution of cost per capita} \tag{20}$$

$$\sum_s \sum_i \left\{ g(d^N_{htsi}) w_{htsi} \right\} \quad \text{Contribution of days per population} \tag{21}$$

$$\sum_s \sum_i \{g(N_{hts}) w_{htsi}\}$$ Contribution of the increase in insured population (22)

Contribution other than population

$$= \sum_s \sum_i \{(g(c^D_{htsi}) + g(d^N_{htsi}) w_{htsi}\} = \sum_s \sum_i \{(g(c^N_{htsi}) w_{htsi}\}$$

$$= \sum_s \sum_i \{GrowthRate\_i-th\_Service\_Cost\_per\_capita\}\{weight\_i-th\_Service\} \quad (23)$$

a. Graphical Presentation

This study utilizes data of h=47 prefectures and t=25 years (1981-2005), s=2 types of the insured (General and Aged) in health insurance plans, i=3 services "Hospitalization", "Outpatient", and "Dental Services". There are four measures C/N, C/D, D/E, E/N and D/N. In order to find patterns of medical cost, this study uses graphical presentation. In sum, y_{htsi} (C/N, C/D. D/E, E/N, D/N of the h-th region, s-th insurance: general and aged, i-th services: hospitalization, outpatient, and dental services) are plotted against years. Also the difference of the original data and the nation mean is introduced.

$$Dif(y_{htsi}) = y_{htsi} - y^*_{tsi} \quad (24)$$

where y^*_{tsi} is the national mean at t-th period, s-th insurance, and i-th service.

b. Decomposition of the Variance

The variance of the medical cost (C/N) is decomposed into "Cost per Day (C/D)", "Days per Event (D/E)", and "Events per Population (E/N)" as equation (24).

$$c^N_{htsi} = \frac{C_{htsi}}{N_{htsi}} = \frac{C_{htsi}}{D_{htsi}} \cdot \frac{D_{htsi}}{E^N_{htsi}} \cdot \frac{E_{htsi}}{N_{htsi}} = c^D_{htsi} \cdot d^E_{htsi} \cdot e^N_{htsi} \quad (25)$$

This is transformed into (25).

$$z = xy, x > 0, y > 0 \quad \log z = \log x + \log y$$

$$Cov(\log z, \log x) = E(\log z \cdot \log x) - \overline{\log z} \cdot \overline{\log x}$$

$$Var(\log z) = Cov(\log z, \log x) + Cov(\log z, \log y)$$

$$Var(\ln c^N_{htsi}) = Cov(\ln c^N_{htsi}, \ln c^D_{htsi}) + Cov(\ln c^N_{htsi}, \ln d^E_{htsi}) + Cov(\ln c^N_{htsi}, \ln e^N_{htsi}) \quad (26)$$

Equation (26) is transformed into (26)' using a relationship

$$Cov(\ln c^N_{htsi}, \ln d^N_{htsi}) = Cov(\ln c^N_{htsi}, \ln d^E_{htsi}) + Cov(\ln c^N_{htsi}, \ln e^N_{htsi})$$

$$Var(\ln c^N_{htsi}) = Cov(\ln c^N_{htsi}, \ln c^D_{htsi}) + Cov(\ln c^N_{htsi}, \ln d^N_{htsi}) \quad (26)'$$

This equation indicates that the regional variance of the medical cost (C/N) is decomposed into the sum of three terms, each of which respectively represents the covariance of the "Medical Cost per Capita(C/N)" with "Cost per Day (C/D)", "Days per Event (D/E)", and "Events per Population (E/N)." By calculating these variance and covariance, we analyze the sources of the regional variance of (C/N) and its convergence. Dividing both sides of equation (25) with the variance yields equation (27).

$$1=\frac{Cov(\ln c^{N}_{htsi},\ln c^{D}_{htsi})}{Var(\ln c^{N}_{htsi})}+\frac{Cov(\ln c^{N}_{htsi},\ln d^{E}_{htsi})}{Var(\ln c^{N}_{htsi})}+\frac{Cov(\ln c^{N}_{htsi},\ln e^{N}_{htsi})}{Var(\ln c^{N}_{htsi})}$$

$$=b_1\,(\ln c^{N}_{htsi},\ln c^{D}_{htsi})+b_2\,(\ln c^{N}_{htsi},\ln d^{E}_{htsi})+b_3\,(\ln c^{N}_{htsi},\ln e^{N}_{htsi}) \qquad (27)$$

$$b_1\,(\ln c^{N},c^{D})=\frac{Cov(\ln c^{N}_{htsi},\ln c^{D}_{htsi})}{Var(\ln c^{N}_{htsi})}$$

$$b_2\,(\ln c^{N},d^{E})=\frac{Cov(\ln c^{N}_{htsi},\ln d^{E}_{htsi})}{Var(\ln c^{N}_{htsi})}$$

$$b_3\,(\ln c^{N},e^{N})=\frac{Cov(\ln c^{N}_{htsi},\ln e^{N}_{htsi})}{Var(\ln c^{N}_{htsi})}$$

We can calculate b_1 , b_2 , and b_3 for the t-th period, s-th insurance, and i-th service. (26) shows how the variance is explained.

c. Econometric Analysis

In growth theory, geographical variation of GDP has been extensively analyzed based on "convergence theory" developed by Barro and Sala-i-Martin,1995.[7] Empirical studies have been conducted with using Japanese cross section and time-series data. For example, Shioji studies convergence of the GDP Japanese prefectures by using panel data (Shioji, 2000)[8]. This method can be applied to medical cost and associated variables.

$$y_{htsi}=\ln q_{htsi}-(\overline{\ln q_{tsi}}) \qquad (28)$$

q_{htsi} : variables related to medical cost including "Cost per capita (C/N) ," "Cost per Day(C/D)", "Days per Event (D/E)", "Events per Population (E/N)" or "Days per Population(D/N)" of h-th region, s-type insured, i-th service, and t-th period.

$\overline{\ln q_{tsi}}$: national mean for q_{htis} . Instead of using the arithmetic mean of each variable for 47 prefectures, we use the national mean because two are different significantly due to the differences in size of regions.

$$\overset{\bullet}{y}_{htsi}=-\delta(y_{htsi}-\overset{*}{y}_{hsi}) \qquad (29)$$

$\overset{*}{y}_{htsi}$ is the level to which y_{htsi} is converged in the long-run. Equation (29) assumes that convergence depends on its speed defined as δ per cent annually and the differences between current level of y_{htsi} and the convergence level $\overset{*}{y}_{hsi}$. δ is positive when there is convergence.. In order to estimate δ by using annual discrete data, we transform (29) into (30).

$$y_{htsi}-\overset{*}{y}_{hsi}=e^{-\delta^{si}}\cdot(y_{ht-1,si}-\overset{*}{y}_{hsi})+u_{htsi} \qquad (30)$$

u_{htsi} is independently and identically distributed random error with $E(u_{hit})=0$ $E(u^{2}_{htsi})=\sigma^{2}I_{htsi}$, where I_{htsi} is

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[7] Barro and Sala-i-Martin, *Economic Growth*, McGraw Hill, 1995.

[8] Etsuro Shioji, "Ch.8, Nihon no Chi-iki Syotoku no Syusoku to Syakai Shihon", in Hiroshi Yoshikawa and Masayuki Otaki ed. *Jyunkan to Seicyo no Macro Keizaigaku*, 2000. University of Tokyo Press.

a diagonal HT × HT matrix which diagonal entry is unity and 0 otherwise.

$$y_{htsi} = e^{-\delta^{si}} \cdot y_{ht-1,si} + (1 - e^{-\delta}) y^{*}_{hsi} + u_{htsi} \qquad (31)$$

when the variable will converge to the same level for all regions $y^{*}_{hsi} = 0$, which convergence is called the "absolute convergence" (Barro and Sala-i-Martin (1995).

$$y_{itsi} = e^{-\delta^{si}} \cdot y_{ht-1,si} + u_{htsi} \qquad (32)$$

We can estimate $e^{-\delta^{si}}$ in equation (32) by applying the OLS to data, then construct the "implied speed of convergence" δ^{si}. Adding additional explanatory variables yield equation (33).

$$y_{htsi} = e^{-\delta^{si}} \cdot y_{ht-1,si} + \sum_{k=1}^{K} \beta^{k}_{si} X^{k}_{htsi} + \sum_{j=1}^{H} \gamma_j D_j + \sum_{l=1}^{M} \tau_l T_l + u_{htsi} \qquad (33)$$

where additional explanatory variables are X^{k}_{htsi} k-th explanatory variables whose coefficients are β^{k}_{si}, D_j is regional dummy variables which equals 1 when $h = j$ and 0 otherwise. Their coefficients are γ_j. T_l is year dummy variables which equals 1 when $t = l$ and 0 otherwise. Their coefficients are τ_l. As a dependent variable y_{hit}, this research uses "Cost per Day(C/D)", "Days per Event (D/E)", "Events per Population (E/N)" and "Days per Population (D/N)" of the s-type insured and i-th services ($\ln c^{D}_{htsi}, \ln d^{E}_{htsi}, \ln e^{N}_{htsi}\ \ln d^{N}_{htsi}$). There are three categories of explanatory variables. First category is economic variables such as GDP per capita of each region. Second category is $\ln c^{D}_{htsi}, \ln d^{E}_{htsi}, \ln e^{N}_{htsi}\ \ln d^{N}_{htsi}$ excluding those used as a dependent variable. The third category is the medical resources variables such as the number of beds per population, physicians per population, nurses per population, aged home capacity per population, and the use rate of hospital beds. For example, we estimate the following equation of C/D along with the $\ln d^{E}_{htsi}$ and $\ln e^{N}_{htsi}$ included in explanatory variables.

$$\ln c^{D}_{htsi} = e^{-\delta^{Asi}} \cdot \ln c^{D}_{ht-1,si} + \beta^{Asi}_{2} \ln d^{E}_{htsi} + \beta^{Asi}_{3} \ln e^{N}_{htsi} + \sum_{k=4}^{K} \beta^{Asi}_{k} X^{k}_{htsi} + \sum_{j=1}^{H} \gamma^{Asi}_{j} D_j + \sum_{l=1}^{M} \tau^{Asi}_{l} T_l + u^{A}_{htsi} \qquad (33\text{-}1)$$

$$\ln d^{E}_{itsi} = e^{-\delta^{Bsi}} \cdot \ln d^{E}_{ht-1,si} + \beta^{Bsi}_{1} \ln c^{d}_{htsi} + \beta^{Bsi}_{3} \ln e^{N}_{htsi} + \sum_{k=4}^{K} \beta^{Bsi}_{k} X^{k}_{htsi} + \sum_{j=1}^{H} \gamma^{Bsi}_{j} D_j + \sum_{l=1}^{M} \tau^{Bsi}_{l} T_l + u^{B}_{htsi} \qquad (33\text{-}2)$$

$$\ln e^{N}_{htsi} = e^{-\delta^{Fsi}} \cdot \ln e^{N}_{ht-1,si} + \beta^{Fsi}_{1} \ln c^{d}_{htsi} + \beta^{Fsi}_{2} \ln d^{E}_{htsi} + \sum_{k=4}^{K} \beta^{Fsi}_{k} X^{k}_{htsi} + \sum_{j=1}^{H} \gamma^{Fsi}_{j} D_j + \sum_{l=1}^{M} \tau^{Fsi}_{l} T_l + u^{F}_{htsi} \qquad (33\text{-}3)$$

$$\ln d^{N}_{htsi} = e^{-\delta^{Gsi}} \cdot \ln d^{N}_{ht-1,si} + \beta^{Gsi}_{1} \ln c^{d}_{htsi} + \sum_{k=4} \beta^{Gsi}_{k} X^{k}_{htsi} + \sum_{j=1}^{H} \gamma^{Gsi}_{j} D_j + \sum_{l=1}^{M} \tau^{Gsi}_{l} T_l + u^{G}_{htsi} \qquad (33\text{-}4)$$

Superscripts of A, B, F, and G are added to distinguish different estimates. Because variables of $\ln c^{D}_{htsi}, \ln d^{E}_{htsi}, \ln e^{N}_{htsi}$, and $\ln d^{N}_{htsi}$ are endogenously determined, OLS results in biased estimates. We use the instrumental variable estimation using one-period lagged variables and other variables as instruments. For example of (33-1),

$\ln d^{E}_{htsi}$ and $\ln e^{N}_{htsi}$ are endogenous variables, we use one-period lagged variables $\ln d^{E}_{ht-1,si}$ $\ln e^{N}_{ht-1,si}$ as instruments. The similar selection of the instrumental variables is made for (33-2), (33-3) and (33-4).

3. Data

Medical cost is taken from the Ministry of Health and Welfare and Labor.[9] The number of hospitals, clinics, and pharmacies, beds, physicians, dentists, pharmacists are taken from the Ministry of Health and Welfare and Labor[10]. Income and GDP deflator of prefecture is obtained from SNA (System of National Account) at prefecture level[11]. Consumer price index is taken from Ministry of Internal Affairs and Communications, Statistics Bureau and the Director"Regional Price Difference Index"[12]. All Yen terms is adjusted by the price index at the year of 2002.

4. Preliminary Analysis

a. Growth of National Medical Cost

We divide sample into 1981-1985, 1986-1990, 1991-1995, and 1996-2000. The growth rate is calculated as the compound annual growth rate between the initial year and the last year of the five-year period[13]. Table 1 summarizes the growth of the medical cost and contribution by components. The growth rate of the number of the "Aged" is higher in 1981-1985 and 1996-2000 than other periods[14]. The former is due to the introduction of the "Health Insurance Plan for the Aged" and the latter corresponds to the growth of the number of the aged population since the late 1990s. Then new health insurance expanded the insured by covering all population older than 70 years old. Table 1 also indicates the growth of the medical cost by types of services using the national means. First panel indicates the share of each service in the medical cost of the Municipal Health Insurance Plan. Shares of the "Aged Hospitalization" and "Aged Outpatient" had grown to 27 per cent and 23 percent respectively[15]. Total medical cost had growth rate 6.7% (1981-1985), 3.8% (1986-1990), 4.8 %(1991-1995), 4.3%(1996-2000). Of the 4.3% growth rate in 1996-2000 period, the "Aged Hospitalization" cost constitutes 1.6% and the "Aged Outpatient" 1.3%. Almost 80 % of the growth rate of medical cost came from the services for the aged services. Contribution of the growth of the number of population for the "Aged Hospitalization" is 1.7%, "Aged Outpatient" is 1.5% in 1996-2000. Most of medical cost growth (4.26%(in 1996-2000 was accounted by the increase in the numbers of the insured (2.8%), while only small part was accounted by other factors (C/D, D/E, E/N). (1.46%).

----Table 1. Growth of Population in the Municipal Health Insurance Plan ----

b. Geographical Trend

i. GDP and Medical Resources

Using graphical presentations, this section analyzes trend and the variance of measures. Figures 1-1 to 1-9

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[9] Ministry of Health and Welfare and Labor, various years, *Kokumin Kenko Hoken Jigyo Nenpo* (厚生労働省 『国民健康保険事業年報』).

[10] Ministry of Health and Welfare and Labor, every year, *Ishi, Shika-ishi Chosa, Yakuzaishi Chosa* (厚生省・厚生労働省『医師，歯科医師調査，薬剤師調査』)

[11] Economic and Social Research Institute, Cabinet Office, SNA Data (経済企画庁・内閣府経済社会研究所 『県民所得統計年報』)

[12] Ministry of Internal Affairs and Communications, Statistics Bureau and the Director, every year, *Zen Koku Bukka Tokei Cyosa Hokoku,* 総理府統計局・総務省統計局 『全国物価統計調査報告』)

[13] Growth rate is calculated as $\sqrt[5]{(X_t / X_{t-5})} - 1$ where t=1986, 1991, 1996, and 2001.

[14] The growth reflects the introduction of the "Health and Medical Service Law for the Aged (*Rojin Kenko Hoken Seido*)" in 1983 by replacing the prior insurance plan for the aged.

[15] Medical cost of the Municipal Health Insurance Plan constitutes about one-thirds of total medical cost of medical cost of Japan. For the aged it constitutes about 70 percent of Japan. Ministry of Health, Welfare, and Labor, various years, *Kokumin Iryohi* (厚生労働省 『国民医療費』).

(Appendix)summarizes GDP and medical resources. Figure 1-1 of GDP indicates that real GDP had not grown much since the 1990s. There were wide differences across regions. Tokyo had maintained the highest GDP that was twice high as the lowest GDP of Okinawa. The variance had, however, shrunk until 2000s, then the variance had expanded again. Figure 1-2 shows doctors per population, 1-2 nurses per population, both of which grew steadily over time, but had large regional differences. For example, Tokyo had the highest doctors per population ratio, while it had lower nurses per population. Beds per population had different pattern in that it had increased up to 1980s, then it had started to decline in the 1990s. This may reflect the government policy to reduce the number of beds. There were wide regional variances. For example, Kochi had by far the highest rate, while Saitama had the lowest. Saitama has also the lowest doctors per population and nurses per population rate. Under investment in Saitama deserves further investigation.

ii. Hospitalization Services

Figures 2-1 to 2-10 summarize cost measurements for the "General" and "Aged" of "Hospitalization". Figures display the trend and the variances with the nation mean along with individual data including prefectures of Hokkaido, Saitama, Tokyo, Nagano, Osaka Tokushima, Kochi, Fukuoka and Okinawa, all of which show unique profiles. The medical cost of per capita (C/N) for the "General" had increased up to the early 1980s, while it had been flattened in the 1990s. In contrast, the cost per day (C/D) had not increased up to 1990s, since then it had started to grow. "Days per Event (D/E)" and "Events per Person (E/N)" had increased moderately up to the early 1990s, then they had declined. The medical cost containment by the government had affected (D/E) and (E/N). There had been wide geographical variations across regions.

The medical cost of the "Aged Hospitalization" had been stable in the 1990s, which might reflect the cost containment of the regions with the higher medical cost. Cost per day (C/D) had started to increase in 1992 in the same manner with the "General Hospitalization". The "Days per Event (D/E)" and "Events per Population (E/N)" had declined significantly in the 1990s for the aged. As a result, the "Days per Population(D/N)" had peaked in the late 1980s and since then continued to declined In particular, regions with higher events per population had reduced their rates in the 1990s (Figure 2-10). Regions with higher "Cost per Day(C/D)" tended to have lower days per event (D/E) and events per population. In sum, he large variances of the aged in the 1980s had rapidly converged by the early 2000s. We should analyze the different patterns of convergence between the general and aged.

iii. Outpatient Services

Unlike "Hospitalization", cost per capita (C/N) for "Outpatient" had increased both for the "General" and "Aged" up to 1997 (Figure 2-11, 2-16), then it became stable until 2003. The aged had become more stable than the general. The increase in C/N for the "Aged Outpatient" is contrasted with the stable C/N for the "Aged Hospitalization." Although the events per population (E/N) for the "General" and "Aged" had increased, "Days per Population (D/N)" had remained fairly stable over periods due to the decline in "Days per Event (D/E)". There are some outliers. For example, Hiroshima had recorded the highest rates C/N and Tokushima had rapidly increased the rates while Okinawa and Tokyo had maintained the lowest rates. "Cost per Day (C/D)" had increased steadily. Okinawa had the highest rates of (C/D) while Tokyo had achieved lower rates both for the "General" and "Aged". Although Okinawa and Tokyo had long achieved lower C/N for outpatient, Okinawa had the highest while Tokyo had lower (C/D). The reasons behind this deserve further examinations. Days per population (D/N) had increased for the "General" in the mid-1990s, while that for the "Aged" had been stable over the periods. Compared with the "General Outpatient", the "Aged Outpatient" had wider variations in D/N across regions.

iv. Dental Services

Figure 2-21 to 2-30 summarizes "Dental" services. There were upward trends for C/N and C/D. Unlike other services, the increase in D/N is due to the rise in E/N. There are large differences across regions for the "Aged" compared with "General". Although both Fukuoka and Osaka had higher cost per capita (C/N), Fukuoka had longer "Days per Event (D/E)" while Osaka had higher "Event per Population (E/N) " than most regions. Okinawa had the lowest C/N both for the "General" and "Aged" because "Events per Population (E/N) " had been far lower than other regions. Patterns of dental services are totally different from the hospitalization and outpatient. These outliers require further investigation with focusing on region specific effects.

v. Comparison

Due to many data, graphical presentation is too difficult to draw stylized patterns. Figure 3-1 to 3-5 (Appendix) show the means of C/N, C/D, D/E, E/N, and D/N by each medical service. Cost per day (C/D) for the hospitalization had been stable up to 1992, since then it had started to increase, while C/D for the outpatient dental services had continued to rise except for the early 2000s. Days per population (D/N) for the general had been stable until the late 1990s, while those for the aged had declined since the late 1980s. Introduction of the long-term case insurance in 2000 is associated with the decline of (D/N). Events per population (E/N) had peaks in 1995 for the general and 1989 for the aged. Both of which had started to increase in the early 2000s, which reasons are not clear without further investigation.

5. Geographical Variance

a. Overview

As seen above, there are significant regional variations of medical resources and cost across prefectures. In order to identify the stylized variation across regions, this study first uses graphical presentation. We use the differences of original measures from the national means.

$$Dif(y_{htsi}) = y_{htsi} - y^{*}_{tsi} \qquad (24)$$

Figure 4-1 to 4-30 in Appendix exhibit the regional variations. There was the convergence of the aged services for most measures, while there was no such convergence for general services. Also some regions were shown to have unique movement. For example, as to the "Aged Hospitalization", Okinawa and Nagano were outliers, while as to the "General Outpatient", Okinawa and Hiroshima were outliers.

Regional variation can be summarized by the statistical measures of the coefficient of variation (CV). Figure 5-1 to 5-4 summarizes the CV of the related measures in natural log form. For example, CV of cost per capita (C/N) had downward trend for the "Aged Hospitalization" , "Aged Outpatient", and "General Dental" while those of the "General Hospitalization" and " General Outpatient" had been stable. In particular, CV for the "Aged Hospitalization" had a steep downward slope around year 2000 when the Long term Care Insurance was introduced. CV for Ln (C/D) had similar trends. CVs for Ln (D/N) exhibit that all medical services except for the "General Dental" had shown the downward slopes. CV for the "General Hospitalization" had a downward slope up to 1992, since then it had increased. Dental services had followed special trend which are distinguished from the other services. The variance of $\ln c^{N}_{htsi}$ for the "Aged Hospitalization" and "Aged Dental" had declined significantly over periods, which trend indicates that the differences across prefectures had become smaller while the variance of "General Hospitalization" and "General Outpatient" had been stable in the long run. In the same manner, the variance of C/D, D/E, and E/N moves significantly.

b. Decomposition of the Variance

We are concerned is the magnitude and sources of the variance. To answer this question equation (25) and (26) are applied.

$$Var(\ln c^{N}_{htsi}) = Cov(\ln c^{N}_{htsi}, \ln c^{D}_{htsi}) + Cov(\ln c^{N}_{htsi}, \ln d^{E}_{htsi}) + Cov(\ln c^{N}_{htsi}, \ln e^{N}_{htsi}) \qquad (26)$$

Figures 6-1 to 6-6 (Appendix) summarize the results. The variance of the "Aged Hospitalization" had declined significantly over the periods up to 2000, while that of the "General Hospitalization" had been flat for the periods. Again the decline in 2000 might reflect the introduction of the Long-term Care Insurance. The covariance of $Cov(\ln c^{N}_{tsi}, \ln c^{D}_{tsi})$ had been negative through out the periods which indicates that the medical cost per day ($\ln c^{D}_{tsi}$) is negatively correlated with the ($\ln c^{N}_{tsi}$) for the hospitalization services. This is interpreted that the regions with higher C/D have lower C/N. $Cov(\ln c_{tsi}^{N}, \ln d_{tsi}^{E})$ had been stable at 0.1-0.2 range except for the sudden drop in 2000. A striking feature is that $Cov(\ln c_{tsi}^{N}, \ln e_{tsi}^{N})$ had been similar to the variance of $Var(\ln c_{tsi}^{N})$. The variance of $\ln c_{tsi}^{N}$ is mostly explained by $Cov(\ln c_{tsi}^{N}, \ln e_{tsi}^{N})$. In contrast, the variance of $\ln c_{tsi}^{N}$ of "General Hospitalization" had not shown convergence. $Cov(\ln c_{tsi}^{N}, \ln c_{tsi}^{D})$ again indicates the negative sign, while $Cov(\ln c_{tsi}^{N}, \ln d_{tsi}^{E})$ had been stable too. $Cov(\ln c_{tsi}^{N}, \ln e_{tsi}^{N})$ is similar with the $Var(\ln c_{tsi}^{N})$. These results are also interpreted by (26) which divides (25) with $Var(\ln c_{tsi}^{N})$.

$$1 = b_1\,(\ln c_{htsi}^{N}, \ln c_{htsi}^{D}) + b_2\,(\ln c_{htsi}^{N}, \ln d_{htsi}^{E}) + b_3\,(\ln c_{htsi}^{N}, \ln e_{htsi}^{N}) \qquad (26)'$$

Figure 6-4 exhibits that $b_3\,(\ln c_{htsi}^{N}, \ln e_{htsi}^{N})$ is about unity both for the "General Hospitalization" and "Aged Hospitalization". This implies that $Var(\ln c_{tsi}^{N})$ is explained by $Cov(\ln c_{tsi}^{N}, \ln e_{tsi}^{N})$, and that effects of $Cov(\ln c_{tsi}^{N}, \ln c_{tsi}^{D})$ and $Cov(\ln c_{tsi}^{N}, \ln d_{tsi}^{E})$ are cancelled out.

The variance of the "General Outpatient" had first increased up to 1993, then it had decreased. The variance is explained both by $Cov(\ln c_{tsi}^{N}, \ln e_{tsi}^{N})$ and $Cov(\ln c_{tsi}^{N}, \ln d_{tsi}^{E})$. The variance of "Aged Outpatient" had been larger than the "General Outpatient" and it had decreased by mid-1990s. The variance is mostly associated with $Cov(\ln c_{tsi}^{N}, \ln d_{tsi}^{E})$. Another interesting feature is that the drop in $Var(\ln c_{tsi}^{N})$ in 1996-1997 is associated with the increase in $Cov(\ln c_{tsi}^{N}, \ln d_{tsi}^{E})$ and $Cov(\ln c_{tsi}^{N}, \ln d_{tsi}^{E})$ in absolute values.

Cost per capita for "Dental" services shows different patterns. The variance of cost per capita for the "Aged" had been much larger than the "General". $Cov(\ln c_{tsi}^{N}, \ln c_{tsi}^{D})$ had been positive but small in magnitude. $Cov(\ln c_{tsi}^{N}, \ln d_{tsi}^{E})$ had declined over the periods, and no correlation was found between $\ln c_{tsi}^{N}$ and $\ln d_{tsi}^{E}$ lately. Most of the variance had come to be explained by $Cov(\ln c_{tsi}^{N}, \ln e_{tsi}^{N})$ (Figure 6-6).

6. Econometric Analysis

Table 2 reports the preliminary estimations of equation (37) by OLS.

$$\ln y_{htsi} = e^{-\delta} \cdot \ln y_{ht-1,si} + u_{htsi} \qquad (32)$$

where y_{htsi} is "Cost per Capita (C/N)" for each services. No convergence is found for C/N of "General Hospitalization", while annual 1-3 percent convergence speed is found for other services. In particular the "Aged Hospitalization" has 2.7 percent speed of convergence. As shown by the graphical presentation in Section 4, each region has its own pattern of the change. In order to capture the regional effects and specific effects, individual dummy variables (47 prefectures) and time dummy variables (year dummy variables 1983-2005) are added to equation (32).

$$\ln y_{htsi} = e^{-\delta} \cdot \ln y_{ht-1,si} + \sum_{j=1}^{H} \gamma_j D_j + \sum_{l=1}^{M} \tau_l T_l \ + u_{htsi} \qquad (34)$$

Compared with Table 2, Table 3 indicates that inclusion of the regional dummy variables has significantly changed the estimate. In particular, speed of convergence for the "General Hospitalization" reached 15.5% and "Aged Hospitalization" 7.8%. Figures 1-3 exhibit the coefficients of time and regional dummy variables. Time effects seem to respond to the official medical price revisions before 1996. The relationship, however, has become weak since the late 1990s. Most of the estimates of the regional dummy variables are significant. For example, the coefficients of regional dummy variables for the hospitalization display are higher in western part of regions where C/N have higher values. Compared with the "Aged Hospitalization", "General Hospitalization" has larger coefficients for regional dummy variables, which might be associated with higher "implied speed" of the convergence. Because geographical presentation and decomposition analysis of the variance did not show any convergence for the "General Hospitalization, " the estimation results could be over-estimate of the convergence due to specification error.

Table 4 summarizes the estimates the following equation for the "General Hospitalization" and "Aged Hospitalization".

$y_{ht} = \ln(z_{ht}) - \overline{\ln(z_{ht})}$, where d_{ht} is the difference between the original variables and their weighted means of the same period.

$z_{ht,T} = d_{ht} - d_{h,t-T}$, where z_{ht} is the difference between the period t and t-T.

$$y_{ht} = e^{-\delta_1} \cdot y_{ht-1} + \sum_{i}^{K} \beta_i X_{ht}^{i} + \sum_{j=1}^{H} \gamma_j D_j + \sum_{l=1}^{M} \tau_l T_l \ + u_{ht}$$

$$y_{ht} - y_{h,t-T} = e^{-\delta} \cdot (y_{ht-1} - y_{h,t-1-T}) + \sum_{i}^{K} \beta_i \, (X_{ht}^{i} - X_{h,t-1-T}) + \sum_{l=1}^{M} \tau_l T_l + (u_{ht} - u_{h,t-T})$$

$$\ln c_{htsi}^{D} = e^{-\delta_1^A} \cdot \ln c_{ht-1,si}^{D} + \beta_2^A \ln d_{htsi}^{E} + \beta_3^A \ln e_{htsi}^{N} + \sum_{k=4}^{K} \beta_k^A X_{htsi}^{k} + \sum_{j=1}^{H} \gamma_j^A D_j + \sum_{l=1}^{M} \tau_l^A T_l \ + u_{htsi}^{A} \qquad (33\text{-}1)$$

$$\ln d_{itsi}^{E} = e^{-\delta_1^A} \cdot \ln d_{ht-1,si}^{E} + \beta_1^B \ln c_{htsi}^{d} + \beta_3^B \ln e_{htsi}^{N} + \sum_{k=4}^{K} \beta_k^B X_{htsi}^{k} + \sum_{j=1}^{H} \gamma_j^B D_j + \sum_{l=1}^{M} \tau_l^B T_l \ + u_{htsi}^{B} \qquad (32\text{-}2)$$

$$\ln e_{htsi}^{N} = e^{-\delta_1^C} \cdot \ln e_{ht-1,si}^{N} + \beta_1^C \ln c_{htsi}^{d} + \beta_2^C \ln d_{htsi}^{E} + \sum_{k=4}^{K} \beta_k^C X_{htsi}^{k} + \sum_{j=1}^{H} \gamma_j^C D_j + \sum_{l=1}^{M} \tau_l^C T_l \ + u_{htsi}^{C} \qquad (33\text{-}3)$$

$$\ln d_{htsi}^{N} = e^{-\delta_1^D} \cdot \ln d_{ht-1,si}^{N} + \beta_1^D \ln c_{htsi}^{d} + \sum_{k=4} \beta_k^D X_{htsi}^{k} + \sum_{j=1}^{H} \gamma_j^D D_j + \sum_{l=1}^{M} \tau_l^D T_l \ + u_{htsi}^{D} \qquad (33\text{-}4)$$

New explanatory variables including $\ln c_{htsi}^{d}, \ln d_{htsi}^{E}, \ln e_{htsi}^{N}, X_{hsit}$ are included based on the assumption that a dependent variable of each region will converges to its level. In particular, inclusion of $\ln c_{htsi}^{d}, \ln d_{htsi}^{E}, \ln e_{htsi}^{N}$ allows interpretations of the relationship among these variables. Also inclusion of GDP and medical resource variables allows interpretations as to the effects of these variables on dependent variable.

For the "Aged Hospitalization", 1 percent increase in C/D has negative effects on D/E (-0.047 higher convergence speed), positive effects on E/N (0.044 lower convergence speed) . 1 percent increase in D/E has negative effects on C/D(-0.316

higher convergence), positive effects on E/N (0.154 lower convergence speed) . Also 1 per cent increase in E/N has negative effects on C/D (-0.046, higher convergence), positive effects on D/E (0.051, lower convergence speed). "General Hospitalization" has similar results except for E/N, for which C/D and D/E have no effects. GDP would increase C/D (0.07, lower convergence speed). Beds per population ratio has positive effects on E/N for the "General" (0.054), but has the negative effects on E/N (-0.047) for the "Aged." Bed use rate has negative effects on E/N for the "Aged Hospitalization". Both "Doctors per Population" and "Nurses per Population" have positive effects on C/D, which indicates the higher human resources would result in the higher medical cost with slower convergence. "Aged Home Capacity per Population" would induce E/N but reduce D/E. By adding explanatory variables, convergence of higher speed is found.

$$\ln c^{D}_{hts} = e^{-\delta_1^A} \cdot \ln c^{D}_{ht-1,s} + \beta_2^A \ln d^{E}_{hts} + \beta_3^A \ln e^{N}_{htsi} + \sum_{k=4}^{K} \beta_k^A X^{k}_{htsi} + \sum_{j=1}^{H} \gamma_j^A D_j + u^{A}_{htsi} \quad (33\text{-}1)$$

$$\ln d^{E}_{itsi} = e^{-\delta_1^A} \cdot \ln d^{E}_{ht-1,si} + \beta_1^B \ln c^{d}_{htsi} + \beta_3^B \ln e^{N}_{htsi} + \sum_{k=4}^{K} \beta_k^B X^{k}_{htsi} + \sum_{j=1}^{H} \gamma_j^B D_j + \sum_{l=1}^{M} \tau_l^B T_l + u^{B}_{htsi} \quad (32\text{-}2)$$

$$\ln e^{N}_{htsi} = e^{-\delta_1^C} \cdot \ln e^{N}_{ht-1,si} + \beta_1^C \ln c^{d}_{htsi} + \beta_2^C \ln d^{E}_{htsi} + \sum_{k=4}^{K} \beta_k^C X^{k}_{htsi} + \sum_{j=1}^{H} \gamma_j^C D_j + \sum_{l=1}^{M} \tau_l^C T_l + u^{C}_{htsi} \quad (33\text{-}3)$$

$$\ln d^{N}_{htsi} = e^{-\delta_1^D} \cdot \ln d^{N}_{ht-1,si} + \beta_1^D \ln c^{d}_{htsi} + \sum_{k=4} \beta_k^D X^{k}_{htsi} + \sum_{j=1}^{H} \gamma_j^D D_j + \sum_{l=1}^{M} \tau_l^D T_l + u^{D}_{htsi} \quad (33\text{-}4)$$

7. Conclusions and Limitations

This study investigates the variance of medical cost across regions and its convergence. Because regional specific effects persist over time and the speed of convergence is the issue, one needs to utilize pooled time-series and cross-section data instead. This study uses "Municipal Health Insurance" data of 47 prefectures in 1981-2005 to analyze "Hospitalization", "outpatient", and "dental" services of the "general" and "aged" population. Expressing the "cost per capita (C/N)" as the product of "cost per day (C/D)", "days per event (D/E)" and "events per population (E/N)", the degrees of the variance and convergence are examined. Large variances and quicker convergence are found both for the "Aged Hospitalization" and "Aged Outpatient". Convergence of the former is associated by the by E/N while the latter by D/E. Although the "cost per capita (C/N)" is negatively correlated to "Cost per Day (C/D)" in the early 1980s, its relationship became weaker lately.

Hospitalization services have higher speed of convergence in C/D, D/E, and E/N, which indicates that the regions with higher C/D have higher convergence speed in D/E (i.e. lower D/E), while higher D/E has higher convergence speed in C/D (lower C/D) . Thus C/D and D/E have a negative trade off. The increase in GDP per capita has slowed the convergence speed in C/D and D/E (lower C/D and D/E) . The increase in physicians (doctors) per population and the nurses per population slowed the speed of convergence of C/D (higher C/D). The capacity of aged home per population increases the convergence speed of D/E (lower D/E) while decreases the speed of E/N (higher E/N). These results have important implications for the hospitalization services. Convergence speed depends on various regional profiles in a complicated manner. Though there are no simple policy recommendations for cost containment, we find followings suggestions. In addition to long-time trend, the regional variance of medical cost is important because each region has inherent path of convergence in some services.. By accounting for the regional difference, we estimate higher than expected speed of convergence. Convergence speed depends on various explanatory variables. Certain causal relationships are important. This study does not single out the clear-cut causal relationship of the convergence of variance. We need further investigation by employing different research method.