The Effect of Cost Containment on the Outpatient in Japan – A VAR Approach

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Abstract

This paper examined the effects of restrictions on both the demand and supply sides of the health sector in Japan over a certain time period. Because the effect of supply side restrictions could not be taken into account in previous studies, we employed econometric time series techniques to develop a four-variable VAR model of the health sector over a sample period from November 1999 to March 2004. We used a first-difference series regarding the number of general beds to capture productivity shock. By using impulse response functions and a forecast error variance decomposition, we found that a price shock dominated the behavior of both patient and physician at forecast horizons, although in the short run the rise in the intensity of treatment leads to a decrease in the rate of doctor consultations. By estimating the structural VAR model under a recursive constraint, it was found that all of the causal links in the model constituted an invalid specification. We concluded that the increase in the patient's coinsurance rate had the effect of restraining health care costs but that a labor productivity shock did not have a permanent effect on the doctor consultation. The supply side of the health sector might absorb the change that occurred in the demand side.

Key Words: Coinsurance rate, Government-managed health insurance, Japan, Labor productivity, Number of beds, Structural shock, Vector autoregressive model

Ⅰ. Introduction

Countries with national health insurance typically rely on supply side constraints to keep expenditures under control. They restrict the number of physicians and beds, and the diffusion of new high-cost medicine. A few studies have addressed the supply side of the health sector in Japan, and it is apparent that none of them could develop the effect of hospital bed reduction by the government over a time period. Previous studies focused on the differential in labor productivity between the health sector and other sectors (Urushi and Yoshikawa 1987, Sato et al. 1997, Sato 2001, Kumagai 2003). Although Kumagai (2003) found that medical prices should be determined annually according to the changes in labor productivity in the health sector, his findings are not useful to control health care expenditures because in Japan the fee schedule is still set by the government every two years.[1]

[1] The employment adjustment depends on the differential in labor productivity between the health sector and the other sectors. By using a vector error correction model, Kumagai (2003) constructed an econometric model of the health sector in Japan. The diffusion process of health technology and the labor productivity in the health sector were interrelated in the model. He found that the ratio of health care expenditures to GDP will not continue to

On the other hand, the increase in the patient's coinsurance rate appears to be an effective policy to restrain health care expenditures in Japan. Kumagai et al. (2005) showed that a 10 percent increase in the effective rate of out-of-pocket payment of insured persons reduced health care cost per outpatient visit by an average of 12 percent. They also found a difference in insured persons and dependents with regard to the effect of the effective rate of out-of-pocket payment to the rate of doctor consultations.[2] Several studies have investigated the effects of the total cost of the demand for health care and found that the increase in non-monetary costs decreased the demand for health and/or health care (Phelps and Newhouse 1974, Acton 1975, Cauley 1987, Ogura 1990, Yamada 2002). Ogura (1990) is the first researcher to examine the non-monetary costs of the representative individuals in Japan based on the invalidity benefit of a health insurance plan by using time series data. He showed that the increase in non-monetary costs decreased the rate of doctor consultations. Yamada (2002) analyzed the demand for health check-ups among persons from 20 to 64 years in age in Japan by using wage rate as the proxy variable for the opportunity costs of health check-ups. He found that the higher opportunity costs tend to lower the examination rate of health check-ups for males, but the same tendency was not found for females.[3] Those studies indicate that non-monetary costs to patients are major determinants of health care expenditures.

Kumagai and Izumida (2007) focused on the change in the cost-sharing rule of Employee's Health Insurance in September 1997 in an evaluation of health insurance policy. Because no previous studies using data on health insurance claims in Japan determine the effect of the increase in the coinsurance rate to the rate of doctor consultations, they employed econometric time series techniques to develop recursive vector autoregressive (VAR) models in order to analyze the effect of unobserved shocks to the outpatient. By using a three-variable VAR model, Kumagai and Izumida (2007) showed that a price shock to the outpatient accounts for about 50 percent of the forecast error variance of health care cost per outpatient visit from the three months to five months after.

Since those studies aimed at demand-side constraints, the effect of the supply-side restriction could not be determined.[4] In this paper, we employ econometric time series techniques to develop a VAR model in order to capture the

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increase if medical prices are annually determined according to the changes in labor productivity in the health sector.

[2] For the insured persons, the coefficient of the effective rate of out-of-pocket payment to the rate of doctor consultations was significantly negative. They considered that part of the difference in the effect of the effective rate of out-of-pocket payment was caused by the magnitude of time costs.

[3] The data covers the ages, sex, and insurance plan of 450,000 individuals in 1995. In his empirical analysis, Yamada (2002) showed that the illness of a person who purchased the services of health check-ups was less serious than that of a person did not purchase it. He argued the differentials in health insurance plans affect the rate of health check-ups since the opportunity costs differ among health insurance plans.

[4] Urushi and Yoshikawa (1987) showed that the optimal health care expenditure was theoretically determined by the population ratio of working people to the elderly, the endowments of health and the other goods, the labor productivity in the health sector, and that in other sectors. Sato et al. (1997) and Sato (2001) conducted numerical simulations using the two-sector model. In their simulations, they manipulated the growth rate of labor productivity in the health sector.

shocks on both the demand and supply sides. The rest of the paper is organized as follows. Section 2 overviews the shocks that have an effect on the health care cost of outpatient. These shocks are caused by changes in the coinsurance rate and the number of beds. Section 3 shows the specification of our VAR model. Section 4 presents the results of the estimation and the effects of shocks on the health care cost of the outpatient over a period time. Finally, we provide concluding remarks in Section 5.

Ⅱ. Shocks in the health sector

In order to identify shocks that have an effect on the health care cost of the outpatient, we use a set of variables representing the both demand side and supply side of the health sector. Our interest in shocks focuses on changes in the coinsurance rate and the number of beds. The hospital bed supply in Japan is subject to central or regional planning, as in Western European countries. We thus consider that the number of beds is exogenous to individual hospitals.

Since the change in the coinsurance rate constitutes a shock for the patient because the change in coinsurance rate affects physician visits directly, we describe an overview of the change in the coinsurance rate of employees in the Japanese public health insurance system. Many people in Japan obtain their insurance via employer-related groups. Until 1997, most of the employer-group plans required co-payments for dependents, with 10 percent co-payments for workers.[5] Japanese public health insurance systems are classified roughly into [1] insurance for employees and their dependents, [2] insurance for the self-employed, retirees and their dependents, and [3] insurance for the elderly aged 70 and over. Retired persons are covered by the plan with contributions from employment and community plans plus funds from both national and local governments, with small co-payments for patients at the time of medical service.

The first type of insurance is Employee's Health Insurance, which consists of Government-managed Health Insurance (GHI), Society-managed Health Insurance (SHI), Mutual Aid Associations (MAA), and Seamen's Insurance. To calculate the total cost of the demand by the outpatient, we focus on GHI because the health insurance system provides invalidity benefit for the insured persons. The total cost per physician visit includes the time cost of the outpatient. The number of enrollees is about 35.8 million (the insured 18.8, the dependents 17.0) in March 2003. An insurer of GHI is the national government. The GHI received around 8.3 percent of an insured's monthly income in the 1990s, evenly splitting between employer and employee.[6] One of the main changes in the 1990s was that the coinsurance rate of employees was raised from 10 percent to 20 percent. This cost-sharing rule changed in September 1997. The coinsurance rate of employees was raised from 20 percent to 30 percent again in April 2003, while the coinsurance rate of dependents stayed the same (30 percent).[7]

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[5] These plans also have a catastrophic cap feature that limits monthly out-of-pocket expenses. Insurance societies or mutual aid societies are established in industries.

[6] Elderly participating in the Japanese health insurance plans were defined in the 1990s as those 70 and over. This definition was changed in the 2000s. GHI includes workers employed by small and medium-size companies. In SHI, large firms organize their own insurance group instead of making their employees enroll in GHI. MAA includes national and local public employees and private school teachers and staff.

[7] Kumagai (2005) investigated whether health care was a necessity for the elderly in the

Contrary to the demand side, reimbursement to health care providers is uniform across regions with little concern for differences in the type of facility or severity of illness because the fee schedule and drug prices are set by the government. According to Campbell and Ikegami (1998), the fee schedule is decided in a key biennial negotiation between insures and providers, and that forum — the Central Social Insurance Medical Care Council (Chuikyo) — has provided a mechanism for dealing with many recurring issues in a routinized way with very restricted participation. Campbell and Ikegami (1998) explained that the Japan Medical Association (Nihon Ishikai) dominates the provider's side in the Central Council in terms of both income growth and their share of medical spending.

Since all reimbursement is regulated by the uniform fee schedule, it is possible for the government to exert moderately rigid control over total expenditures. We used change rates in medical fees as a deflator of the outpatient costs because we could not relate the change in medical fees and physician behavior using aggregated data. Therefore, the change in medical fees is not a shock to the provider of health services in the current paper. The number of beds is an important exogenous variable that affects the labor productivity in the hospital. The change in the number of beds is a supply-side shock because it changes the capital-labor ratio. Since the shocks in both demand and supply side are caused by the government, we construct a VAR model to analyze the effect of these shocks.

Ⅲ. The Model

We construct a model of the insured persons in Japan assuming there are the following relationships among the variables in the demand side. Equation (1) shows that total cost per physician visit at time t is defined as the sum of the money cost per physician visit ($p_t I_t$) and the time cost per physician visit (tp_t). The money cost per physician visit is the product of I_t and an effective rate of out-of-pocket payment (p_t).[8] The amount of benefits paid per physician visit at time t (I_t) deflated by the change rate in medical fees includes both the costs of medical care and the expenses of medicine while excluding dental costs. Q_t is the rate of doctor consultation which is the number of physician visits of the insured person divided by the insured person covered of GHI at time *t*. Error terms ε_{it} are uncorrelated shocks [9]

1990s by using quarterly data regarding age group. He found that the characteristics of health care expenditures directly depend on the effect of changes in out-of-pocket payments. Using vector error correction models with an attention paid to structural changes of payment, he concluded that health care expenditures were a luxury for the elderly.

[8] According to Phelps and Newhouse (1974) and Ogura (1990), time cost was obtained by multiplying 0.4 and earned income per day. Since the invalidity benefit per day of GHI is 60 percent of an earned income per day, the weight of the time cost is 0.4. Time cost can be seen as an opportunity cost of work hours. By dividing an average earned income per month by 25 days, we can determine earned income per day.

The coinsurance rate of employees participating in GHI was increased by 20 percent and the cost-sharing rule of medicine was introduced in September 1997.

[9] We consider that health care cost per outpatient visit is a stochastic variable which is determined by the physician. The physician can change the intensity of treatment and determine the set of medical services, although each fee for medical services is defined by the governments.

$$c_t = p_t I_t + tp_t \quad (1)$$

$$c_t = f(c_{t-i}) + \varepsilon_{1t} \quad (2)$$

$$Q_t = g(c_t, Q_{t-i}) + \varepsilon_{2t} \quad (3)$$

$$I_t = h(Q_t, I_{t-i}) + \varepsilon_{3t} \quad (4)$$

Assuming that the amount of labor is variable and the amount of capital is fixed in the short run, the marginal product of labor to the patient is determined by the amount of labor

$$ML_t = \gamma_0 + \gamma_1(L_t), \gamma_1 > 0 \quad (5)$$

Health care cost per physician visit as an output of health production is explained by the amount of labor and the unforecastable productivity shock.

$$I_t = \delta_0 + \delta_1(L_t) + u_t^s, \delta_1 > 0 \quad (6)$$

By subtracting each side of Equation (6) from Equation (5), we can obtain Equation (7) which represents the relationship between health care cost per outpatient visit and the marginal product of labor. Positive productivity shock has a negative impact on the marginal product of labor. It can be considered that the physician cannot expect a change in the number of beds. Therefore, we can define the productivity shock as Equation (8)

$$ML_t = \phi_0 + \phi_1(I_t) + \varepsilon_{4t} \quad (7)$$

where $\phi_0 = \gamma_0 - \frac{\gamma_1 \delta_0}{\delta_1}$, $\phi_1 = -\frac{\gamma_1}{\delta_1}$, $\varepsilon_{4t} = -\frac{\gamma_1 u_t^s}{\delta_1}$.

$$u_t^s = K_t - K_{t-1} + e_{Kt}, \quad (8)$$

where K_t is the number of general beds at time *t*, and e_{Kt} is an error term.

Equation (9) shows that health care cost per outpatient visit is equivalent to the product of the intensity of treatment and the average product of labor. The intensity of treatment is the amount of labor in the health sector per physician visit. The average product of labor is the health care cost of the outpatient per amount of labor in the health sector. The amount of labor includes the worker-hour for inpatient services.

$$I_t = DoT_t \cdot AL_t \quad (9)$$

For the sake of simplicity, suppose $ML_t = DoT_t$. We can thus represent the intensity of treatment as $DoT_t = k(I_t, Q_t, AL_t(DoT_{t-i}))$.

We then can derive Equations (10) and (11) from Equations (2), (3), (4), (7), and (9).

$$DoT_t = k(c_{t-i}, Q_{t-i}, I_{t-i}, DoT_{t-i}, u_t^s) \quad (10)$$

$$I_t = h(c_{t-i}, Q_{t-i}, DoT_{t-i}, I_{t-i}, u_t^s) \quad (11)$$

We integrate Equations (2), (3), (10), and (11) to obtain a pth-order VAR model.[10] The matrix A_0 in Equation (12) contains an (4×1) vector of intercept terms, and each matrix A_i contains 4^2 matrices of coefficients.

$$X_t = A_0 + A_1 X_{t-1} + A_2 X_{t-2} + \cdots + A_p X_{t-p} + e_t, \quad (12)$$

where $X_t = \begin{bmatrix} c_t \\ Q_t \\ I_t \\ ML_t \end{bmatrix}$, $e_t = \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{bmatrix}$.

A model can be chosen which allows us to use the type of recursive system proposed by Sims (1980) and recover the estimates of the $\{e_t\}$ sequences. A VAR constructs the error terms in each regression equation to be uncorrelated with the error in the preceding equations, although the Choleski decomposition actually makes a strong assumption regarding the underlying structural errors.[11]

Ⅳ. Empirical analysis

We estimate the model in Equation (12) over the sample period from November 1999 to March 2004. The number of observations is 53. The rate of doctor consultations, health care cost per outpatient visit, and the effective rate of out-of-pocket payment were calculated based on data from the "Annual Operational Report" of the Social Insurance Agency. The amount of labor in the health sector and the number of general beds were obtained from "The Operational Index of the Third Industrial Sector" of the Ministry of Commerce and Industry and the "Census of Medical Care Institutions and Hospital Reports" of the Ministry of Health, Labor and Welfare, respectively. The empirical work in this study is based on a sample of monthly observations covering October 1999 to March 2004. We could obtain the sequences of the number of general beds over the sample period from October 1999 to September 2004, though some of the other variables were not available after

[10] We used the variable u_t^s as an exogenous variable in the estimation function if δ_1 is estimated a large positive value, ε_{4t} does not capture the productivity shock.

[11] Estimation of each regression equation by ordinary least squares produces residuals that are uncorrelated across equations. In the jargon of VARs, this algorithm for estimating the recursive VAR coefficients is equivalent to estimating the reduced form, then computing the Cholesky factorization of the reduced form VAR covariance matrix (Stock and Watson 2001). Decomposing the residuals in the triangle fashion is called the Choleski decomposition. This decomposition forces a potentially important asymmetry on the system.

April 2004. The definition and descriptive statistics of variables for this study are summarized in Table 1. All the variables used in the following regression analysis were seasonally adjusted using the Census X12 method.

1. Data and causality among the variables

The sudden changes in both the rate of doctor consultations and health care cost per outpatient visit were observed in April 2003 when the coinsurance rate of employees was raised from 20 percent to 30 percent. We can consider that a hike in the coinsurance rate has a lasting effect since there is little tendency for the rate of doctor consultations to revert to an average value before April 2003.

Figure 2 shows the series of the intensity of treatment in the health sector and the number of general beds. We can see a boost in the intensity of treatment in April 2003. The number of general beds was reduced over the period October 2002 to March 2004. Because the capacity for inpatients gradually decreased, we can consider that the change in the rate of doctor consultations had a great influence on the intensity of treatment. According to the MEDIAS (Medical Information Analysis System) of the Ministry of Health, Labor and Welfare, the change rate in the number of beds in terms of size of hospital from October 2002 to October 2005 was as follows: a decrease by 0.52 percent in total, a decrease by 7.59 percent in the smallest group (20～49 beds), and an increase by 1.4 percent in the group with 100 or more beds (100～199 beds). We can infer that some hospitals stopped providing inpatient services in recent years and as a result the intensity of treatment has increased.

Table 1 Definition and Descriptive Statistics of Variables

Sample: 1999:10-2004:03

Variables	Definition	Mean	Median	Maximum	Minimum	Std. Dev.	Variational Coefficient
Total cost per physician visit	Sum of the money cost and the time cost per physician visit, 1000yen	7.783	7.715	8.108	7.646	0.150	0.019
The rate of doctor consultations	The number of physician visits of the insured person / the insured person covered of GHI	0.437	0.440	0.469	0.405	0.014	0.032
Health care cost per outpatient visit	Amount of benefits paid per physician visit deflated by the change rate in medical fees, 1000yen	12.822	13.104	13.427	11.518	0.637	0.050
Number of general beds (Ippan Byosyo)	Number of general beds, 2000:01=1.00	1.104	1.105	1.220	0.990	0.090	0.081
Intensity of treatment	Index of amout of labor in the health sector / Index of number of physician visits, 1998:01=1.00	1.121	1.112	1.304	0.994	0.080	0.071

Sources: the Social Insurance Agency "Annual Operational Report",
the Ministry of Commerce and Industry "The Operational Index of the Third Industrial Sector",
the Ministry of Health, Labor and Welfare "Census of Medical Care Institutions and Hospital Reports"

Note: The seasonally adjusted number of general beds in January 2000 is 1266885.

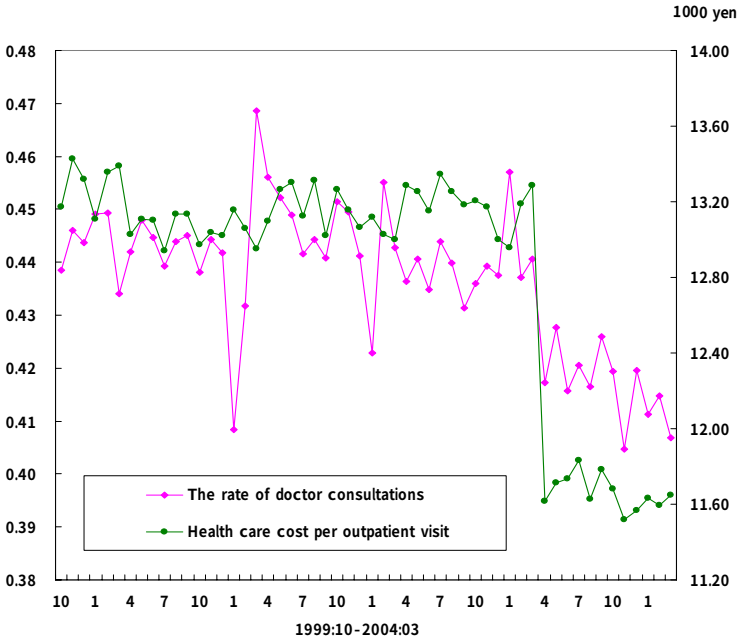

Figure 1 Doctor consultations and health care cost per outpatient visit

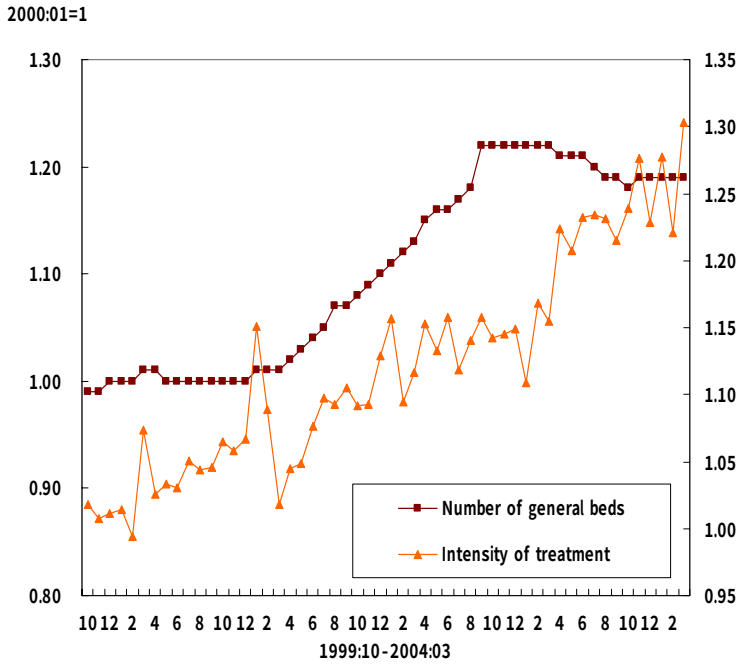

Figure 2 General beds and the intensity of treatment in the health sector

To perform the standard statistical inferences in a regression analysis in which non-stationary time series data are used, the data generating processes of the variables concerned were analyzed using the unit root tests in which a special attention must be paid to the existence of a trend and structural breaks. As the

result of the Perron tests (Perron 1989, 1994), the unit root hypothesis was rejected at the 5 percent significance level for the level series of total cost per physician visit, health care cost per outpatient visit, and the intensity of treatment. A structural break point in April 2003 was exogenously given. The Perron tests are elaborated in the Appendix. According to Dickey-Fuller tests (Dickey and Fuller 1979), the unit root hypothesis was rejected at the 1 percent significance level for the level series of the rate of doctor consultations and for a first difference series of the number of general beds.

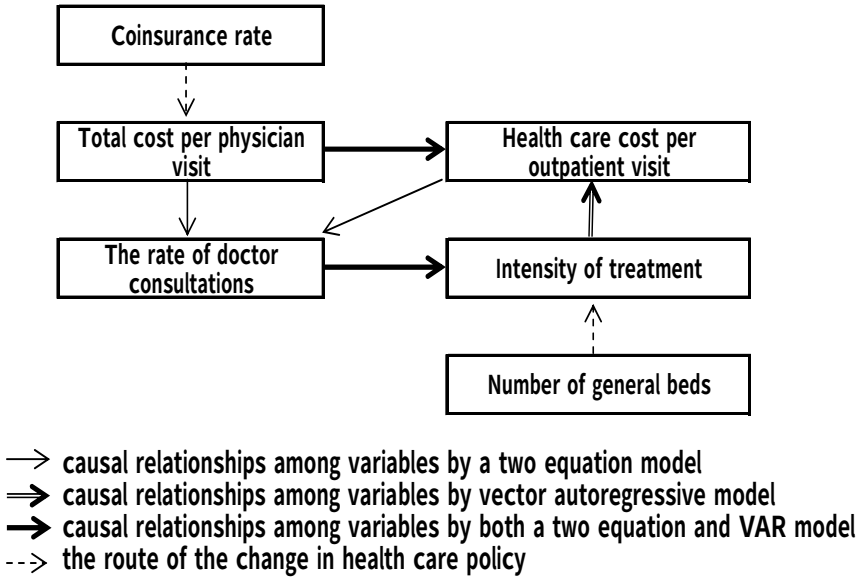

Figure 3 Causality among the variables

Granger-causality statistics examine whether the lagged values of one variable helps to predict another variable. As the result of Granger's causality test at the 5 percent significance level, five causal relationships among the variables were found. Two types of tests were conducted. One was a two-equation model and the other was a four variable VAR model. Lags of 2 and 4 were tested. The method of Granger's causality test involving a two-equation model is given in the Appendix. The relationships among the variables are depicted in Figure 3. The dotted lines indicate the route of change in health care policy. Each of the bold arrows in Figure 3 implies that X causes Z. The series of the rate of doctor consultations causes the series of the intensity of treatment. The series of total cost per physician visit and the intensity of treatment cause health care cost per outpatient visit. As the result of the block causality test, we found that any lags of the rate of doctor consultations, the intensity of treatment and health care cost per outpatient visit did not cause total cost per physician visit at the 5 percent significance level.[12] According to the results of causality tests, we determined an ordering of the variables as follows:

$c_t \rightarrow Q_t \rightarrow ML_t \rightarrow I_t$.

[12] The multivariate generalization of the Granger causality test is called a block causality test.

2. VAR

As explained in Footnote (10), we used a first difference series in the number of general beds as an exogenous variable sufficient to capture the productivity shock in the estimation of a recursive VAR (hereafter VAR). Table 2 shows the results of the estimation. All variables in the VAR are transformed into natural logs. As the results of likelihood ratio tests, we can find that the Chi-square criterion for the optimal lag length of the VAR suggests 2 lags in Table 3. Both the AIC (Akaike Information Criterion) and SBIC (Schwarz-Bayesian Information Criterion) showed the second-order of lag length (AIC=-23.63, SBIC=-22.15). As the result of the estimation, we found that the increase in total cost per physician visit for the patient in the preceding term significantly increased the intensity of treatment and reduced health care cost per outpatient visit during this term. We therefore can consider that the increase in the patient's coinsurance rate is an effective policy to restrain health care expenditures.

On the other hand, the expected sign of the coefficient of a shock such as hospital bed reduction to marginal labor productivity is positive since the number of general beds gradually decreased in the latter half of the sample period (See Equation 7). However, the estimated coefficient of the number of general beds was not statistically significant in the equation of the intensity of treatment. We then consider that the reduction of the capacity for inpatient care did not boost the intensity of treatment of outpatient care. The doctor consultations by the dependents may slightly affect the intensity of treatment in the health sector. It should be noted that the estimated coefficient of the number of general beds in relation to health care cost per outpatient visit was significantly positive. This result infers that the decrease in the number of general beds by 1 percent reduced health care cost per outpatient visit by an average of approximately 1000yen ($1.01=\exp(0.01\times1.104\times1.059)$). When the number of general beds is reduced in the fee-for-service system, we consider that hospitals with a large number of beds will increase their occupancy rates and keep patients hospitalized for as long as possible. Because the insured person does not substitute inpatient services for outpatient services although the elderly does make this substitution, we can consider that the reduction of the number of general beds might decrease the health production for outpatient care.

Table 2 Four-variable VAR model of the health sector

	Total cost per physician visit	The rate of doctor consultations	Intensity of treatment	Health care cost per outpatient visit
Total cost per physician visit (-1)	0.633	-0.706	1.103	-1.279
	[3.56]	[-1.28]	[1.98]	[-2.89]
Total cost per physician visit (-2)	0.077	0.122	-0.417	-0.247
	[0.43]	[0.22]	[-0.75]	[-0.56]
The rate of doctor consultations (-1)	-0.054	0.090	0.054	-0.200
	[-0.58]	[0.31]	[0.18]	[-0.87]
The rate of doctor consultations (-2)	0.145	-0.297	1.175	0.038
	[1.46]	[-0.96]	[3.77]	[0.15]
Intensity of treatment (-1)	-0.081	-0.024	0.036	-0.191
	[-0.97]	[-0.09]	[0.13]	[-0.92]
Intensity of treatment (-2)	0.107	-0.127	1.087	-0.065
	[1.27]	[-0.49]	[4.14]	[-0.31]
Health care cost per outpatient visit (-1)	-0.111	-0.045	0.036	0.303
	[-1.68]	[-0.22]	[0.17]	[1.84]
Health care cost per outpatient visit (-2)	0.008	0.274	-0.238	-0.139
	[0.12]	[1.37]	[-1.18]	[-0.87]
Constant	0.934	-0.369	0.119	5.153
	[1.53]	[-0.19]	[0.06]	[3.40]
First difference in the nunber of general beds	-0.197	-0.149	0.259	1.059
	[-1.27]	[-0.31]	[0.53]	[2.75]
R-squared	0.877	0.598	0.911	0.896
Adj. R-squared	0.851	0.514	0.892	0.874
Sum sq. resids	0.002	0.022	0.023	0.014
S.E. equation	0.007	0.023	0.023	0.018
F-statistic	34.047	7.104	48.621	41.189

Sample: 1999:11 2004:03
All variables in the VAR are transformed into natural logs.
T-statistics are in the parenthesis.

Table 3 Lag lengths of the VAR based on likelihood ratio tests

	Total cost per physician visit	The rate of doctor consultations	Intensity of treatment	Health care cost per outpatient visit	Joint
Lag 1	30.30	3.28	5.31	27.15	54.77
	[0.0000004]	[0.51]	[0.25]	[0.000001]	[0.0000003]
Lag 2	2.29	2.99	18.95	1.46	136.13
	[0.68]	[0.56]	[0.0008]	[0.83]	[0.0000000]

Sample: 1999:11 2004:03 Chi-squared test statistics for lag exclusion.
Numbers in the parenthesis are p-values.

3. Impulse response functions

In order to identify impulse response, we impose an additional restriction on the VAR system. We used the Choleski decomposition and then identified the VAR. We thus trace the time paths of the effects of pure shocks. The behavior of the dependent variables in response to the shocks can be represented by plotting the impulse response functions. Impulse responses trace out the responses of each of the variable's current and future values to a one-unit increase in the current value of one of the VAR errors, assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero.

It can be considered that a price shock represents an unforecastable change in total cost per physician visit. The impulse responses in the first 24 periods are given in Figure 4. Figure 4 plots the impulse responses of total cost per physician visit, the rate of doctor consultations, the intensity of treatment and health care cost per outpatient visit to an innovation which is equivalent to one standard deviation in a price shock with 95 percent confidence bands. Responses to a price shock apparently diminish over a period of two years. The responses of the rate of doctor consultations and health care cost per outpatient visit share similar patterns.

Since an exogenous variable captures the change in the capital productivity, we consider that a labor productivity shock is an unforecastable change in the intensity of treatment. On the left side of Figure 5, the impulse responses in the first 24 periods are shown while on the right side the impulse responses in the first 60 periods are shown. This figure shows that a labor productivity shock leads to an increase in total cost per physician visit. However, the rise in the intensity of treatment leads to a decrease in the rate of doctor consultations in the short run. The responses of health care cost per outpatient visit to a labor productivity shock apparently diminish over a period of five years. A possible explanation for these results is that a labor productivity shock does not have a permanent effect on doctor consultations.

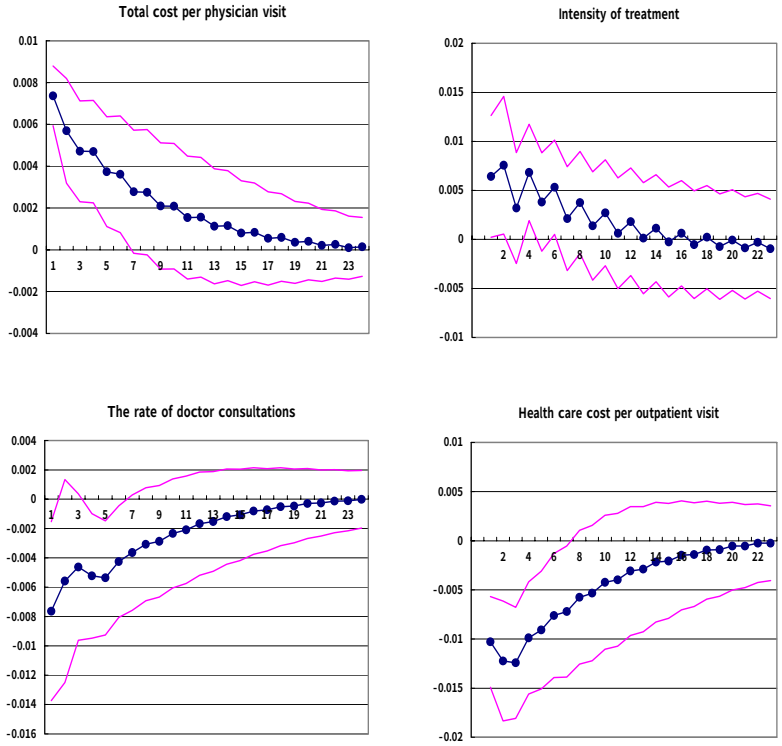

Figure 4 Responses to a price shock

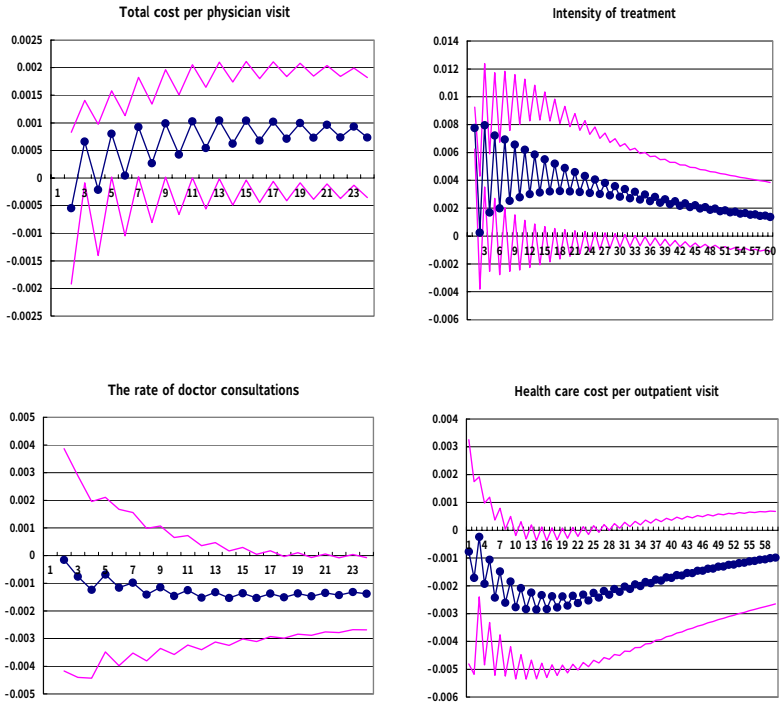

Figure 5 Responses to a labor productivity shock

4. Variance decomposition

Table 4 gives the results of the forecast error variance decomposition. We can see the contributions of the different shocks to the one-step forecast error variance of total cost per physician visit, to the rate of doctor consultations, to the intensity of treatment, and to health care cost per outpatient visit. Table 4 shows that a price shock accounts for about 66 percent of the forecast error variance of health care cost per outpatient visit after the first four months.[13] However, a price shock accounts for about 30 percent of the forecast error variance of the rate of doctor consultations after a year. Although a labor productivity shock accounts for about 1 percent of the forecast error variance of health care cost per outpatient visit in the first four months, the effect of labor productivity shock to health care cost per outpatient visit tended to grow for a period of twenty months. These results may indicate that physicians react rapidly to the change in total cost per physician visit.

Table 4 Contributions of the shocks

		Proportions of forecast error variance *h* periods ahead accounted for by innovations in			
Forecast error in the growth of	Forecast horizon *h*	Total cost per physician visit	The rate of doctor consultations	Intensity of treatment	Health care cost per outpatient visit
Total cost per physician visit	1	100.00	0	0	0
	4	94.51	0.78	0.56	4.15
	8	93.55	1.10	1.27	4.08
	12	92.22	1.36	2.40	4.02
	24	88.01	1.83	6.35	3.82
	60	83.01	2.14	11.22	3.63
The rate of doctor consultations	1	11.17	88.83	0	0
	4	21.27	73.56	0.33	4.84
	8	28.55	65.91	0.95	4.59
	12	30.15	63.47	1.88	4.50
	24	29.71	61.12	4.84	4.33
	60	28.66	58.78	8.39	4.17
Intensity of treatment	1	7.78	80.90	11.32	0
	4	20.42	58.98	16.56	4.05
	8	22.83	48.88	24.87	3.42
	12	21.41	44.35	31.16	3.08
	24	17.85	37.75	41.84	2.56
	60	16.30	32.63	48.79	2.28
Health care cost per outpatient visit	1	31.57	4.24	0.18	64.01
	4	65.74	2.15	0.95	31.16
	8	70.80	2.46	2.26	24.49
	12	70.63	2.74	4.11	22.52
	24	66.23	3.28	9.93	20.56
	60	61.09	3.59	16.44	18.88

[13] Exogeneity is equivalent to the condition that a variable's own innovations account for all of its variance (Sims 1980).

5. Structural shocks

An analysis of responses to a price shock may be complicated since physicians will react to a change in total cost per physician visit. We thus require a simultaneous determination of all the variables above. This implies that all of the causal links in the structural VAR must be specified. In order to identify these structural shocks, we first consider a reduced form of the model without deterministic terms.

$$X_t = A_1 X_{t-1} + \cdots + A_p X_{t-p} + u_t \tag{13}$$

The fundamental shocks are expressed in terms of the structural form

$$AX_t = A_1 X_{t-1} + \cdots + A_p X_{t-p} + B\varepsilon_t, \tag{14}$$

where A and B are invertible matrices of dimension $k \times k$ and ε_t is a $k \times 1$ vector containing the unobservable structural disturbances. It is assumed that structural shocks are mutually uncorrelated and the variance of the structural shocks are normalized to one, so that

$$\sum_{\varepsilon} = E[\varepsilon_t \varepsilon_t'] = I_k . \tag{15}$$

Equation (14) represents that the way structural shocks enter the system is determined by the structure of B. Equation (14) can be related to Equation (16) by premultiplying the inverse of A. Equation (16) relates the reduced form disturbances u_t to the underlying structural shocks ε_t .

$$\begin{aligned} X_t &= A^{-1}A_1 X_{t-1} + \cdots + A^{-1}A_p X_{t-p} + A^{-1}B\varepsilon_t \\ &= \Gamma_1 X_{t-1} + \cdots + \Gamma_p X_{t-p} + u_t \end{aligned} \tag{16}$$

where $\Gamma_1 = A^{-1}A_1, \cdots, \Gamma_p = A^{-1}A_p$ *and* $u_t = A^{-1}B\varepsilon_t$

We can obtain the following equation by premultiplying A,[14]

$$B\varepsilon_t = Au_t \quad . \tag{17}$$

[14] SVAR requires identifying assumptions that allow correlations to be interpreted causally. Using the relationship between ε_t and u_t , we can impose 10 nonlinear restrictions since the symmetry of $\sum_u$ and the orthonormality assumption of the structural shocks imposes $k(k+1)/2$ restrictions on the elements of A and B.

Using Equations (15) and (17), we can represent the structural shocks via the following equation:

$$\varepsilon_t = B^{-1}Au_t . \tag{18}$$

The results of estimating SVAR under a recursive constraint indicate the series of structural shocks as follows:

$$\varepsilon_t = \begin{pmatrix} \varepsilon_{ct} \\ \varepsilon_{Qt} \\ \varepsilon_{MLt} \\ \varepsilon_{It} \end{pmatrix} = \begin{pmatrix} 0.01u_{ct} \\ (10.3) \\ -1.04\varepsilon_{ct} + 0.02u_{Qt} \\ (-2.58)\quad (10.3) \\ -0.12\varepsilon_{ct} - 0.96\varepsilon_{Qt} + 0.01u_{MLt} \\ (-0.81)\quad (-19.47)\quad (10.3) \\ -1.23\varepsilon_{ct} + 0.08\varepsilon_{Qt} - 0.10\varepsilon_{MLt} + 0.01u_{It} \\ (-4.21)\quad (0.30)\quad (-0.38)\quad (10.3) \end{pmatrix},$$

where $B = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1.04 & 1 & 0 & 0 \\ 0.12 & 0.96 & 1 & 0 \\ 1.23 & -0.08 & 0.10 & 1 \end{bmatrix}, A = \begin{bmatrix} 0.01 & 0 & 0 & 0 \\ 0 & 0.02 & 0 & 0 \\ 0 & 0 & 0.01 & 0 \\ 0 & 0 & 0 & 0.01 \end{bmatrix}.$

Because some of the z-statistics in the parentheses were not statistically significant, we rejected a simultaneous determination of all the variables. It was concluded that all of the causal links in the structural VAR under a recursive constraint constituted an invalid specification.

Ⅴ. Conclusions

Previous studies showed that the increase in the coinsurance rate of the patient appears to be an effective policy for restraining health care expenditures in Japan. However, those studies focused on demand-side constraints, and the effect of the supply side restriction could not be taken into account. In this paper, we employed econometric time series techniques to develop a VAR model in order to capture the shocks on both the demand and supply sides.

Assuming that the amount of capital in the health sector was fixed in the short run, we constructed a model for insured persons in Japan. In the model, health care cost per outpatient visit was explained mainly in terms of total cost per physician visit and unforecastable productivity shock. The increase in total cost per physician visit for the patient in the previous month significantly increased the intensity of treatment and reduced health care cost per outpatient visit in this month. We used

a first-difference series in the number of general beds as an exogenous variable sufficient to capture the productivity shock in the estimation of a VAR. The estimated coefficient of the number of general beds in relation to health care cost per outpatient visit was significantly positive. This result infers that the decrease in the number of general beds reduced health care cost per outpatient visit. When the number of general beds is reduced in the fee-for-service system, we consider that hospitals with a large number of beds will increase their occupancy rates, and keep patients hospitalized as long as possible. To maximize hospital revenues, inpatient cost per day may increase even though the later days of hospitalization are less costly. On the other hand, the insured person does not substitute inpatient services for outpatient services. Consequently, the reduction of the number of general beds might decrease health production for outpatient care.

By using impulse response functions and forecast error variance decomposition, we also found that a price shock dominated the behavior of both patients and physicians at the forecast horizons although the rise in the intensity of treatment leads to a decrease in the rate of doctor consultations in the short run. Taking into account the possibility of a simultaneous determination of all the variables, we estimated a structural VAR model to identify the structural shocks. Because some elements of the matrix of a structural VAR were not statistically significant, we concluded that all of the causal links in the structural VAR under a recursive constraint constituted an invalid specification.

We found that the change in total cost per physician visit affects health care cost per outpatient visit during a period of two years and then concluded that the increase in the patient's coinsurance rate had the effect of restraining health care costs but that labor productivity shock did not have a permanent effect on the doctor consultations. What caused this difference between the response to a price shock and the response to a labor productivity shock? We guess that the supply side of the health sector may absorb the change that occurred in the demand side due to the shocks. Finally, the effect of a coinsurance rate increase on dependents will be investigated in further research since the dependents' responses to the change in the effective rate of out-of-pocket payments are not identical to the responses of insured persons.

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Appendix

Perron tests were conducted using Equations (A1) and (A2). In the following, the structural break point (TB) is April 2003. The null hypothesis of a one-time jump in the level or a unit root process against the alternative of a one-time change

in the intercept of a trend-stationary process. If $\theta = 1, \beta_1 = \beta_2 = 0$ are statistically significant, the null hypothesis of a unit root process is accepted. The alternative hypothesis of whether $\theta < 1, \beta_1 \neq 0, \beta_2 \neq 0$ is tested.

$$y_t = \alpha_1 + \alpha_2 DU_t + \alpha_3 D(TB)_t + \beta_1 t + \theta y_{t-1} + \sum_{j=1}^{k} \theta_i \triangle y_{t-i} + \varepsilon_t \quad \text{(A1)}$$

$$y_t = \alpha_1 + \alpha_2 DU_t + \alpha_3 D(TB)_t + \beta_1 t + \beta_2 DT_t + \theta y_{t-1} + \sum_{i=1}^{k} \theta_i \triangle y_{t-i} + \varepsilon_t \quad \text{(A2)}$$

where DU_t represents a dummy level variable such that DU_t =1 if $t > TB$ and 0 otherwise and $D(TB)_t$ represents a dummy pulse variable such that $D(TB)_t$ =1 if $t = TB + 1$ and 0 otherwise. The alternative hypothesis for $t > TB$ posits a trend-stationary series with a change in the slope of the trend, where DT_t represents a time-trend dummy variable such that DT_t = t if $t > TB$ and 0 otherwise.

The Results of Perron Tests

Sample: 1999:10 2004:03

		Coefficient	Standard Error	t-Statistic		
Total cost per physician visit	Constant term	1.591	0.17	9.24	R-squared	0.943
	DU	0.035	0.00	9.53	Adjusted R-squared	0.941
	Preceding term	0.221	0.08	-9.24	Standard Error of regression	0.005
					Durbin-Watson stat	1.629
Intensity of treatment	Constant term	-0.453	0.07	-6.11	R-squared	0.911
	DU	0.039	0.01	3.45	Adjusted R-squared	0.906
	Time trend term	0.004	0.00	6.49	Standard Error of regression	0.022
	Preceding term	-0.065	0.14	-7.76	Durbin-Watson stat	1.916
Health care cost per outpatient visit	Constant term	2.147	0.19	11.17	R-squared	0.926
	DU	-0.105	0.01	-11.14	Adjusted R-squared	0.924
	Preceding term	0.168	0.07	-11.17	Standard Error of regression	0.013
					Durbin-Watson stat	1.810

DU=1 (t >TB) , DU=0 (otherwise)

Granger's causality or non-causality is concerned with whether the lagged values of an explanatory variable improve on the explanation of dependent variables in a two-equation model. Granger's causality test using a standard F-test was conducted using Equation (A3),

$$\begin{aligned} x_t &= \bar{x} + \sum_{i=1}^{n} \alpha_i x_{t-i} + \sum_{j=1}^{m} \beta_i z_{t-j} + \varepsilon_{1t} \\ z_t &= \bar{z} + \sum_{i=1}^{n} \gamma_i z_{t-i} + \sum_{j=1}^{m} \delta_i x_{t-j} + \varepsilon_{2t} \end{aligned} \quad \text{(A3)}$$

where $\bar{x}$ and $\bar{z}$ are the means of x_t and z_t, respectively. All variables in

Equation (A3) are stationary variables.

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