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Physician-patient Interaction and the Provision of Medical Services Under Different Co-payment Schemes

by

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Physician-patient Interaction and the Provision of Medical Services Under Different Co-payment Schemes

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Abstract

This paper investigates how physicians in Japan changed the quantity of medical services provided to patients in response to the move from a fixed to a proportional co-payment system for the elderly. A physician–patient interaction model is proposed where a physician first decides the quantity of medical services. The patient then sets the number of visits. The paper empirically analyzes whether physicians actually changed the quantity of medical services associated with the co-payment scheme, and if so, in which particular services. The results indicate that a physician provides more services to patients whose co-payment would decrease following the reform, and less to patients whose co-payment would increase. This is achieved through changing the quantity of laboratory testing and/or diagnostic imaging.

Keywords: Co-payment scheme, physician-induced demand, physician–patient interaction
JEL classification: I10, I11, I18

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1. Introduction

Most OECD countries that adopt public health systems have suffered from a surge in public spending for health care services. In particular, spending for the elderly is rapidly growing because of aging populations. As in many other countries, Japan has a health service system for the elderly and has experienced growing pressure on the costs of sustaining this system. In an attempt to control public spending in this area, governments in Japan have gradually increased out-of-pocket payments, or co-payments, for elderly patients.

In general, persons more than 70 years old are eligible to benefit from the health services system. One of the main features of the system is that the elderly pay lower co-payments than those under 70 years of age. In 2000, a proportional co-payment scheme was introduced, whereby the elderly became obliged to share 10 percent of the total monthly medical fee, in place of a per-visit fixed co-payment in the prereform scheme where the monthly co-payment was unrelated to the monthly fee. The rationale was that the increase in patients' cost-share leads to a decrease in patient visits and thus reduces the total medical fee. In fact, if patient visits are elastic with respect to the co-payment rate, this reform will reduce overall government spending for health care of the elderly.

The reform, however, may not depress the number of visits immediately, even if demand is elastic. One reason is that the effects of the reform are not necessarily the same for all elderly patients. There are potentially two types of patients in this regard: the first is a patient whose co-payment would increase, while the second is a patient whose co-payment would decrease after the reform if treatment were unchanged. For example, a patient whose total medical fee per visit is no more than 5000 yen (about US$45) would pay less in co-payments than they did before the reforms and may therefore increase the number of visits. Whether the reform actually reduces the number of visits by the elderly depends on the relative population size of the two types of patient. Put differently, if the population of the first type is larger than the second, the reform will fail in reducing public spending for elderly health care.

A more important point to be considered is how physicians respond to the reform because it is not sufficient to focus only on patient visits. If the reform reduces the demand for health care services, it would also decrease physicians' income. A physician concerned with pecuniary incentives may then attempt to mitigate the negative effects of the reform by controlling both the number of patient visits and the type of treatment received.

Particularly in elderly health care, a physician is likely to know a patient's demand function, and thus how the change of co-payment affects the patient's visits. In general, elderly diseases are chronic, but not serious. Representative diseases include high blood pressure or troubles with joints, which are not acute but sometimes cause difficulties in patients' daily lives. They may also lead to more serious diseases in the long run. As chronic diseases are relevant to patients' lifestyles, patients tend to inform their physician so the physician becomes aware of their health condition. As a result, patients will not easily move away from a well-informed physician. As physicians know about their elderly patients' lifestyles, they may also understand their way of thinking, and sometimes the value of their assets or income. Thus, a physician may be able to predict whether the reform will encourage or discourage a patient to visit because the patient's demand function for medical services is known.

Furthermore, since the physician sets the medical fee, and given the fee-for-service reimbursement scheme in Japan, the physician also knows each patient's 10 percent co-payment. The physician can then mitigate the negative income effects of the reform by giving more medical services to a patient whose co-payment will fall, and less to a patient whose co-payment would rise if treatments were left unchanged. Thus, physicians can maintain their income, even when the demand for health care services is elastic with respect to the co-payment rate. This implies the reform may have little role in reducing total medical fees.

The purpose of this paper is twofold. The first is to propose a simple physician–patient interaction model to explain both patient visits and physician provision of medical services. The second purpose is to examine empirically how behavior has changed following the reform and whether it is consistent with the expectations of the model. We assume that patients and physicians maximize their respective utilities (or payoffs) and that there is a two-stage decision-making process where the physician moves first followed by the elderly patient. In this model, the physician decides the quantities of medical services using the known demand function of the patient in the first stage; in the second stage, the patient decides how many times he or she will visit the doctor each month, given the quantities of medical services provided by the physician. The physician can then control the number of visits via the quantity of provided services to maximize the payoff.

With the physician–patient interaction model, we anticipate that physicians will provide more medical services to patients whose co-payment falls, and less to patients whose co-payment rises, in order to maximize their own payoff. This has already been proven, as there are a number of papers that suggest physicians change treatment when the prices of medical services are changed by reforms to the fee schedule. For example, Nguyen and Derrick (1997) and Yip (1998) show the possibilities for changes in the supply side when Medicare prices are reduced. In particular, we establish that physicians control the quantity of medical services by changing the frequency of laboratory tests and/or diagnostic imaging.

This analysis is novel in considering the interaction between physicians and elderly patients in a two-stage model based on the Japanese health care system. A number of studies have examined physician behavior from the viewpoint of demand inducement in a fee-for-service reimbursement scheme or patient behavior from a moral hazard point of view. However, only a few studies have discussed the interaction between physicians and patients (Lien et al., 2004). Ma and McGuire's (1997) examination of physician–patient interaction (rationing, effort or persuasion) is a rare example. Our study is inspired by these analyses to model the interaction in the Japanese public health system, which is different from that of the United States. We incorporate two kinds of medical services into the model to examine which kind of services a physician changes when changing the quantity of services provided.

The paper is organized as follows. Section 2 explains briefly the public health insurance system in Japan and provides a literature survey. Section 3 introduces the physician–patient interaction model and Section 4 presents the empirical results. Section 5 concludes.

2. Background and Previous Literature

In the 1970s, an elderly health care system was introduced in Japan to help the aged visit doctors more easily as with Medicare in the US. Initially, there was no co-payment for the elderly, defined as more than 70 years old. While the free provision of medical services by the government improved the health conditions of the aged, it resulted in large deficits in the public health insurance budget. In the 1980s, the free-provision policy was abandoned and a fixed co-payment scheme was introduced. However, even with the fixed co-payment scheme, elderly patients paid only a small amount of money per month for many expensive medical services. In 2000, a proportional co-payment scheme was adopted to reduce the increase in public medical spending for the aged. Before these reforms, an outpatient was required to pay 530 yen (about US$5) per visit for up to four visits, costing about 2120 yen (nearly US$20) per month, and was not required to pay any more, even with more than five visits. After the reform, patients are now required to pay 10 percent of the total fee, although there is still an upper limit for co-payments per month.

We note that competition between medical institutions in Japan is severe and this also influences physicians' behavior. For example, hospitals that provide both primary and advanced health care services compete against clinics. In the Japanese health system, there is no strict separation in the medical services provided by institutions, clinics or hospitals. There is also no distinction between general practitioners and specialists and no separation of hospital fees from doctors' fees. Furthermore, there is no set criteria for attending a hospital or clinic, so patients may choose either, regardless of the seriousness of their illness. Since hospitals compete against clinics (typically run by general practitioners), physicians in hospitals will try to prevent their patients moving to a competitor by keeping patients' utilities greater than their reservation utilities.

We will now discuss how this study is related to previous work. Patients may consume excess health services if they are insured, called an *ex post* moral hazard. The *ex post* moral hazard may be controlled by letting patients bear some portion of the total medical cost. As discussed above, an increase in the co-payment rate may not actually decrease the number of visit to doctors. Manning et al. (1987), using RAND experimental data, reported that the demand for medical services is rather inelastic with respect to the co-payment rate (see Newhouse and the Insurance Experiment Group (1993) for details). Chiappori et al. (1998) studied the effects of an increase in the co-payment rate on patient visits using French data; Cockx and Brasseur (2003) did the same using Belgian data, and Yoshida and Takagi (2002) using Japanese data. The effects found were a general decrease in demand, but these were small and limited to a specific medical service (Chiappori et al., 1998) or were larger for dependents than for the head of the household (Yoshida and Takagi, 2002). None of these, however, examined if the change in the co-payment rate affected physicians' behavior as information on physician treatment was apparently unavailable. On the other hand, as the data set used in this paper was collected at hospitals, we are able to examine this possibility.

The possibility that physicians may change treatment according to their own pecuniary incentives has been referred to as physician-induced demand (PID). Fuchs (1996) indicates that "fee-for-service" reimbursement schemes encouraged physicians to induce demands. The notion of PID was introduced by Evans (1974) and was developed in theory by Reinhardt (1985), Farley (1986), and McGuire and Pauly (1991), to name a few. The models in these studies are characterized by the incorporation of physician norms in physicians' utility function to restrain pecuniary incentives. Empirical studies in this context include, for example, Gruber and Owings (1996), Yip (1998), Scott and Shiell (1997), and Giuffrida and Gravelle (2001). Yip (1998), using US data, concluded that physicians whose incomes were reduced the most by Medicare fee cuts performed higher volumes of coronary artery bypass graft surgeries; Scott and Shiell (1997), using Australian data, found that GPs who used content-based descriptors were just as likely to prescribe, counsel, and treat compared to GPs who used time-based descriptors; and Giuffrida and Gravelle (2001), using UK data, found that the introduction of differential fees for GP and deputy visits in April 1990 led GPs to increase their own visits and reduce the number made by deputies.

In the context of PID, patients have no way of influencing a physician's decision. As argued in Section 1, patients have some bargaining power with physicians, partly because they can independently decide the number of visits and partly because they can change physicians if they wish. Because health service providers in Japan face a situation where there is competition among medical institutions and no gatekeeper monitoring entry to medical institutions, it is not so easy for physicians to induce demand. Asymmetric information between a physician and a patient does not appear to matter as much in this situation, as theoretically suggested by Emons (1997, 2001).

A few studies have attempted to study both physicians' pecuniary incentives and patients' moral hazard in the context of optimal insurance contracts. Zeckhauser (1970) is a pioneer, and Ma and McGuire (1997) generalize Zeckhauser's model. In their models, a physician decides the "effort" in advance and then a patient chooses the quantity of treatment given the "effort". McGuire (2000) focuses on physician-agency, where physicians decide the quantity of treatment to maximize their payoff subject to the constraint that the net benefit of a patient should be no less than the reservation benefit. Although physicians compete, patients will not change their physician as long as their net benefit is greater than the reservation benefit.

Our study follows this line of research such that a patient and a physician interact with one another as independent players in health systems characterized by fees-for-service, unrestricted access to providers (no-gatekeeper systems), and publicly predetermined fees-per-item. We model the behavior as a two-stage game where a physician decides the quantity of treatment in the first stage and a patient decides the number of visits in the second stage. This features both physicians' and patients' behavior under the elderly health care systems.

3. Interaction between Physicians and Patients

In this section, we present our model, which describes patients' and physicians' behavior and then predicts how they change their behavior when a proportional co-payment scheme is introduced in place of a fixed co-payment. A physician is assumed to maximize his or her payoff, defined as the difference between the reimbursement rate of the medical fee and the actual cost of providing the medical service, by way of changing the quantity of medical services provided. A patient maximizes utility by deciding the number of visits given the provided medical services.

3.1. Patients' behavior

The patient maximizes the following utility function,

$$U(c, \mathbf{x}, n) \equiv \alpha_1 \ln c + \alpha_2 \ln(h + n\boldsymbol{\theta}'\mathbf{x}), \quad U \geq \bar{U}, \tag{1}$$

where c is the composite consumption goods, h is the patient's initial health stock, $\mathbf{x}$ is a quantity vector of medical services per visit, n is the number of visits in a given period (a month in this case), and $\boldsymbol{\theta}$ is a vector of the marginal effects of the treatments on patient health. Utility should be no less than the reservation utility, $\bar{U}$.

We assume the patient knows $\boldsymbol{\theta}$, which means that she knows the contribution of the medical services to her health and thus there is no asymmetric information between a patient and a physician associated with medical services. Although asymmetric information is an important issue in health economics, we believe it does not matter as much with elderly outpatients. Because diseases of the elderly are in most cases chronic, patients know well their diseases and the contribution of the medical services to their health condition. Ma and McGuire (1997) and McGuire (2000) also assume this symmetry in information between a physician and the patient.

The patient decides how often she visits a physician each month, n, given the quantity of medical services, $\mathbf{x}$, under her budget constraints, Eq. (2) for the fixed co-payment or Eq. (3) for the proportional co-payment scheme:

$$c + fn = y - tn, \tag{2}$$

$$c + p\boldsymbol{\varphi}'\mathbf{x}n = y - tn \tag{3}$$

In the budget constraints, $\boldsymbol{\varphi}$ is a vector of the reimbursed medical fee per unit of medical service, f is the fixed co-payment per visit, which is irrelevant to $\mathbf{x}$**,** p is the co-payment rate, and t is the opportunity cost per visit. Note that the price of the composite consumption good is normalized to one. Then $p\boldsymbol{\varphi}'\mathbf{x}$ is the co-payment a patient should have to pay out-of-pocket, which depends on the quantity of medical service $\mathbf{x}$. We can then obtain the optimal number of visits in both the fixed and the proportional co-payment schemes[1]:

$$n = (1-\delta)\frac{y}{f+t} - \delta\frac{h}{\boldsymbol{\theta}'\mathbf{x}}, \tag{4}$$

$$n = (1-\delta)\frac{y}{p\boldsymbol{\varphi}'\mathbf{x}+t} - \delta\frac{h}{\boldsymbol{\theta}'\mathbf{x}}, \tag{5}$$

where $\delta = \alpha_1/(\alpha_1+\alpha_2)$.

From Eq. (4) and Eq. (5), we can see that the number of visits is determined by two factors in both cases: one is the co-payment plus the opportunity cost of a visit as a proportion of income, namely, the cost of a visit. This is represented by the first term on the right-hand side of Eq. (4) and Eq. (5). The other is the proportion of improvement of health provided by medical services to the health stock, which is represented by the second term. The larger the cost of a visit to income or the smaller the improvement of health to health stock, the fewer times a patient visits the physician.

We now consider how the patient's visits change when the cost-share scheme is reformed from fixed co-payment to proportional co-payment. If a physician does not change the treatments following the reform, the number of visits depends only upon the cost of a visit. The number of visits increases if $p\boldsymbol{\varphi}'\mathbf{x}+t < f+t$ after the reform and vice versa. Therefore, there are two groups of patients whom the reform adversely affects: one group is encouraged because of the lowered cost of visits and the other is discouraged. In general, a patient with a relatively severe chronic disease, such as diabetes, suffers because of an increase in co-payment, while one with less severe diseases, such as joint trouble, enjoys a decrease.

3.2. Physicians' behavior

Because physicians know the health and economic conditions of their patients and thus the demand functions described by Eq. (4) and Eq. (5), they can exploit this to

[1] In fact, there is an upper limit for the total co-payment per month under both the fixed and the proportional co-payment schemes. In the case of a fixed co-payment scheme, the patient should pay co-payment for no more than four visits and pay no co-payment for the fifth visit and thereafter. Thus the budget constraint is different for these cases, but we neglect this for the sake of simplicity in the model. It is not difficult but trivial to consider two cases, a case below the limit and the case of the limit. In our study, there are usually no more than four visits per month.

maximize their payoffs. The physician evaluates in advance how often a patient visits if given a certain amount of medical services, $\mathbf{x}$, and then maximizes the payoff with respect to $\mathbf{x}$.

A physician's payoff is defined as the difference between the reimbursement of the medical fee calculated item by item with the fee schedule and the actual cost of the provided medical services. Defining $\boldsymbol{\gamma}$ as a vector of actual unit costs of the services, then the payoff per patient's visit given the service quantity $\mathbf{x}$ is $\boldsymbol{\varphi}'\mathbf{x} - \boldsymbol{\gamma}'\mathbf{x}$. The unit cost includes not only the cost of the medicines, but also the unit labor cost for co-medical staff and any other variable costs. McGuire (2000, p. 475) uses the same objective function for the profit-maximization behavior of physicians[2].

The physician maximizes the payoff subject to the insurer-imposed constraints on the quantities and combinations of medical services. To prevent fraud claims from physicians under a fee-for-service reimbursement scheme, the insurer often investigates the claims on which the items and the quantities of medical services provided by a physician are described. The insurer checks if the combination of items is invalid or if the quantities are excessive. The physician's problem is then

$$\begin{aligned} &\max_{\{\mathbf{x}\}} : \prod = n\boldsymbol{\varphi}'\mathbf{x} - n\boldsymbol{\gamma}'\mathbf{x} \\ &\quad s.t. \quad R(\mathbf{x}) \le M \end{aligned} \tag{6}$$

where the constraint represents the permissible combination of the medical services. We assume that the set of feasible combinations of the services $\{\mathbf{x} : R(\mathbf{x}) \le M\}$ is convex. With this constraint, the insurer can control the medical fee per visit below the maxima, namely the maximized value of $\boldsymbol{\varphi}'\mathbf{x}$ subject to $R(\mathbf{x}) \le M$.

Since the physician knows the patient's demand function, the payoff functions for the fixed and proportional co-payment schemes are:

$$\Pi^f = \left[(1-\delta)\frac{y}{f+t} - \delta\frac{h}{\boldsymbol{\theta}'\mathbf{x}}\right](\boldsymbol{\varphi} - \boldsymbol{\gamma})'\mathbf{x}, \tag{7}$$

and

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[2] In Section 4, we empirically examine the validity of the model with microdata from two hospitals. Since there is no categorization of doctor fees in the fee schedule, a physician cannot identify which part of the profit reimbursed from the insurance association should be attributed to her. We assume that the physician behaves so as to maximize the profits of the hospital worked for as if she owns the hospital.

$$\Pi^p = \left[(1-\delta)\frac{y}{p\boldsymbol{\varphi}'\mathbf{x}+t} - \delta\frac{h}{\boldsymbol{\theta}'\mathbf{x}} \right] (\boldsymbol{\varphi}-\boldsymbol{\gamma})'\,\mathbf{x} \tag{8}$$

We classify the medical services into two types, type-1 denoted by x_1 and type-2 denoted by x_2. Type-1 services are laboratory tests and/or diagnostic imaging, which will not directly improve the patient's health condition. Typical type-2 health services include medicine prescriptions, surgical operations, and consultations, which will directly ease physical or psychological damage.

These two types of medical services have different effects on patients' visits following two assumptions. First, we assume that type-2 services improve patients' health conditions, but type-1 services do not, that is $\theta_1 = 0$, for simplicity. Of course, type-1 services may be necessary for determining proper treatment and thus will indirectly contribute to a patient's health condition. This also implies, however, that a patient does not become healthier if only laboratory tests or diagnostic imaging are conducted. In fact, the contribution of type-1 services to health, particularly in chronic diseases, is relatively small when compared to that of type-2 services. Second, we assume the profit margin rates with respect to x_1 and x_2, namely the profit margin defined as $\boldsymbol{\eta} = \boldsymbol{\varphi} - \boldsymbol{\gamma}$ divided by the unit fees in x_1 and x_2, are the same, that is $\frac{\eta_1}{\gamma_1} = \frac{\eta_2}{\gamma_2}$, or equivalently, $\frac{\eta_1}{\varphi_1} = \frac{\eta_2}{\varphi_2}$. This is often the case in the fee schedule because the unit fee is determined as (1 + margin rate) * unit cost as based on surveillance of the market prices of medicines or wages of co-medical staff. With these two assumptions, increasing type-1 services does not improve the health condition of a patient nor increase visits, but does contribute to the physician's payoff as much as type-2 services.

A physician has to consider how to change type-1 or type-2 services when the co-payment scheme is reformed from the fixed to the proportional co-payment scheme. We first clarify the conditions for the optimal combinations of the services in both the fixed and the proportional co-payment schemes and then consider how a physician will change the two types of medical services after the reform.

In the equilibrium, the marginal rate of substitution should equal the tangent of the constraint condition the insurer imposes, namely, R_{x2}/R_{x1}, where R_{x1} or R_{x2} are partial derivatives of $R(\mathbf{x})$ with respect to x_1 or x_2. In the fixed co-payment scheme, we can obtain the marginal rate as

$$-\left.\frac{dx_1}{dx_2}\right|_{\Pi^f=const} = \frac{\eta_2}{\eta_1} + \frac{1}{\partial\Pi^f / \partial x_1}\frac{\delta h}{\theta_2}\cdot\frac{1}{x_2^2}\left(\eta_1 x_1 + \eta_2 x_2\right), \tag{9}$$

where

$$\frac{\partial\Pi^f}{\partial x_1} = \left[\frac{(1-\delta)y}{f+t} - \frac{\delta h}{\theta_2 x_2}\right]\eta_1. \tag{10}$$

Details are discussed in Appendix A. In the same way, we can also derive the marginal rate of substitution in the proportional co-payment scheme as

$$-\left.\frac{dx_1}{dx_2}\right|_{\Pi^p=const} = \frac{\eta_2}{\eta_1} + \frac{1}{\partial\Pi^p / \partial x_1}\frac{\delta h}{\theta_2}\cdot\frac{1}{x_2^2}\left(\eta_1 x_1 + \eta_2 x_2\right) \tag{11}$$

where

$$\frac{\partial\Pi^p}{\partial x_1} = \left[\frac{(1-\delta)yt}{\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2} - \frac{\delta h}{\theta_2 x_2}\right]\eta_1. \tag{12}$$

The optimal combination of the two services is determined by equating the rate of substitution, Eq. (9) or Eq. (11), to the tangent of the constraint.

Let us see how a physician will change the quantities of medical services after the reform starting with the equilibrium under the fixed co-payment scheme. Comparing the marginal substitution rate of the fixed co-payment, Eq. (9), with the proportional co-payment, Eq. (11), we find that the two equations are the same except for the marginal payoffs with respect to x_1 in the second terms. The marginal payoffs of the two co-payment schemes defined as Eq. (10) for the fixed and as Eq. (12) for the proportional, are different for the first terms in the brackets. If the co-payment per visit in the proportional co-payment, namely $p\boldsymbol{\varphi}'\mathbf{x}$, is somewhat smaller than that in the fixed co-payment, *f*, or more precisely speaking, if $\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2 < t(f+t)$ holds, the marginal payoff of the proportional co-payment is larger than the fixed co-payment and vice versa. Note that the condition $\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2 < t(f+t)$ means the patient's disease is light since the number of per-visit medical services, $\boldsymbol{\varphi}'\mathbf{x}$, is small. Then, under the condition where the co-payment of a patient in the case of the proportional co-payment is small, the absolute value of the marginal rate of substitution of the proportional co-payment scheme is smaller at the equilibrium point in the fixed co-payment scheme. We can conclude that a physician will increase x_1 while decreasing x_2 to maximize the payoff when the co-payment scheme changes from fixed to proportional. This is because the marginal payoff with respect to x_1 in the proportional co-payment scheme is larger than the fixed co-payment. Increasing x_1 along the insurer-imposed constraint, $R(\mathbf{x}) \leq M$, is then profitable for the physician. On the other hand, if the co-payment per visit is large, or more precisely speaking, if $\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2 > t(f+t)$ holds, a physician will increase x_2 while decreasing x_1 along the constraint [3].

Figure 1 illustrates this reasoning. We will explain the above results intuitively with the figure. The equilibrium is $\mathbf{E}_f$ under the fixed co-payment scheme and we will start from here, where $\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2 < t(f+t)$. After the proportional co-payment is introduced, a physician will change the combination of x_1 and x_2 to maximize the payoff. The physician cannot, however, change the combination arbitrarily because of the constraints imposed by the insurer, so will consider first how to change x_1 and x_2 while keeping the payoff level at $\mathbf{E}_f$ under the constraint, which implies changing x_1 and x_2 along the tangent line of Π^p at $\mathbf{E}_f$. Since the line is gentler than the tangent line of Π^f , the increase in x_2 and decrease in x_1 along the line of Π^p results in moving outside the constraint. Thus the physician has to increase x_1 while decreasing x_2 and finds the better combination of x_1 and x_2 at $\mathbf{E}_p$ where the marginal rate of substitution is the same as the tangent of the constraint.

In general, two medical services, x_1 and x_2, have different paths that affect a physician’s payoff. The latter has direct effects by expanding the cost-reimbursement margin and indirect effects by increasing patient visits through enhancing utility. The former has only direct effects since we assume that type-1 medical services, such as laboratory tests or diagnostic imaging, make no direct contribution to patient health. We cannot increase x_1 and x_2 at the same time because of the constraint imposed by the insurer. Thus, physicians will consider which is better for their own payoff: increasing x_1 (and decreasing x_2) or decreasing x_1 (and increasing x_2). It then depends on whether the marginal payoff with respect to x_1 or x_2 is larger. The physician will expand the cost-

[3] These results depend on the fact that both Π^f and Π^p are concave functions.

reimbursement margin by increasing x_1 rather than luring patient visits by increasing x_2 because the marginal payoff by increasing x_1 is larger. This also implies that x_2 is excessive at $\mathbf{E}_f$ after the proportional co-payment scheme has been introduced. In other words, a physician provides more medical services of form x_2 in the fixed co-payment scheme than in the proportional co-payment scheme if the disease is less severe, because under fixed co-payment the physician has to be concerned only with luring patient visits, but not with the cost of the visit.

In the case of $\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2 > t(f+t)$, where the disease is more severe, the reverse holds; that is, inducing visits by increasing x_2 is more profitable, even after taking into account the reduction of margin obtained by decreasing x_1.

The total medical fee, $m \equiv \boldsymbol{\varphi}'\mathbf{x}$, at $\mathbf{E}_p$ can be proved to be higher than that at $\mathbf{E}_f$ when $\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2 < t(f+t)$; otherwise it is lower. Since the slope of the line, $m = \boldsymbol{\varphi}'\mathbf{x}$, is the same as the first terms of the marginal substitution rates, Eq. (9) and Eq. (11), because of the assumption $\frac{\varphi_2}{\varphi_1} = \frac{\eta_2}{\eta_1}$, the slope is gentler than the marginal rates of substitution of the fixed and proportional co-payment schemes at $\mathbf{E}_p$ or $\mathbf{E}_f$. The total medical fees of these two equilibriums are expressed as the intercepts of the lines running on $\mathbf{E}_p$ or $\mathbf{E}_f$. Since $\mathbf{E}_p$ is located above the line of the medical fee that runs on $\mathbf{E}_f$ when $\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2 < t(f+t)$, the intercept of the line running on $\mathbf{E}_p$ is higher than the line running on $\mathbf{E}_f$ and vice versa.

In summary, we can provide the following predictions when a proportional co-payment scheme is introduced in place of fixed co-payment. A patient's total medical fee become larger when his/her total cost of doctor visits, including the copayment and the opportunity cost, would be less under the proportional co-payment scheme and if the physician provided the same treatment. Then the number of type-1 medical services increases and the number of type-2 services decreases. On the other hand, the total medical fee becomes smaller when the total cost of doctor visits would be more under the proportional co-payment scheme.

4. Empirical Studies

We use health insurance claims data from two hospitals, one located in Tokyo (Hospital A) and the other in Osaka (Hospital B)[4]. These hospitals have a similar number of beds (about 400), and nearly the same kinds of specialties, including internal medicine, surgery, and ophthalmology. Outpatient claims by patients who were more than 70 years old and who visited hospital at least once during both the pre- and postreform periods were collected for the 12 months before the reform, and for six months after the reform[5]. Note that claims by patients are sent from the physician (or the hospital) to the insurer once a month so that the total number of claims would be twelve if a patient visits at least once every month of the year.

In the claim data, the following information is reported: the monthly number of doctor visits; total medical fee decomposed into 10 categorized medical services and the co-payment; diagnoses; and the kinds of medicines and their units. The total fee is calculated based on the fee schedule, where medical services are disaggregated into many items down to the finest detail and some points are attributed to a unit of each item, where one point is valued at 10 yen. The fee categories for medical services are *base*, *consultation*, *doctor-visit*, *medication*, *injection*, *physical therapy*, *operation*, *laboratory test*, *diagnostic imaging*, and *others*. Thus, we can see which categories a physician increases or decreases following the reform.

We classify patients into two groups, one where the co-payment rate rose after the reform (patient-1) and the other where it fell (patient-2). This classification corresponds to the grouping of patients theoretically discussed in the previous section. The patients are classified according to whether or not $\left(p\boldsymbol{\varphi}'\mathbf{x}+t\right)^2 < t(f+t)$ holds, which is nearly the same as the condition $p < f/\boldsymbol{\varphi}'\mathbf{x}$; that is, the postreform co-payment rate is smaller than the actual co-payment rate under the fixed co-payment scheme. Although the co-payment rate is, in principle, 10 percent following the reform, the rates of a small portion of patients are less than 10 percent because they are subsidized by the

[4] These two hospitals are prestigious hospitals that provide both outpatient and inpatient services or both primary and high-level medical care services.

[5] The difference in the data-gathering periods before and after the reforms may cause bias in the number of visits since patients rarely visiting a physician are likely to drop from the data set. The elderly with chronic diseases, however, often visit a physician so that not as many patients are removed.

government for some other reason. Thus, the co-payment rates are calculated by dividing the total co-payment by the total medical fee aggregated in each surveillance period, 12 months for the prereform period and six months for the postreform period. Even after this calculation, most co-payment rates are 10 percent in the postreform period.

Our strategy to test whether physicians changed medical services in quantity or category for the patient-1 and patient-2 groups is as follows. First, we test whether the quantities of medical services changed after the reform. If this is the case, we then test which category or categories of medical services changed. These tests are referred to as tests of **between-period differences**. We expect that physicians provide more services for patient-2 and less for patient-1. These tests, however, do not examine if the direction of the changes between the two groups is significantly different. Accordingly, we test for whether the direction of change is significantly different by comparing the changes of the two groups between the pre- and postreform periods, which are referred to as tests of **between-group differences**. We take differences in the medical fees between the two periods for the patient-1 and patient-2 groups, and then compare the distribution of the between-period fee-differences between the groups. Finally, we test if we can capture the changes of the quantities associated with the reform or if the grouping of samples into patient-1 and patient-2 is valid. We are concerned that, if the tests capture only the periodical changes of medical services, that is, when the quantities of the medical services to a patient are smaller than in previous periods, then they are likely to become larger for the same patient in the next period. This may happen, for example, when laboratory tests are conducted periodically, say, once every year. Alternatively, Galton’s regression fallacy may apply. We will therefore check that changes in the quantities of medical services are not caused by possible periodical changes or by Galton’s regression fallacy.

4.1. Between-period differences

Table 1 shows the means and the standard deviations of the basic statistics relevant to physician and patient behavior. The number of patients in the patient-1 category in

Hospital A is 3621 (84%) and the patient-2 category is 690 (16%), while in Hospital B the patient-1 number is 932 (43%) and the patient-2 number is 2179 (57%). The co-payment rates rise from 4.66% to 9.51% in Hospital A and from 6.61% to 9.69% in Hospital B in patient-1, while they fall from 16.36% to 9.65% and from 21.17% to 10.46% in patient-2, respectively[6].

Let us examine the data of Hospital A. The expected visits per month and the expected fee per month are calculated by dividing the total visits or the total medical fee, respectively, for the months of the surveillance period by the number of months. Note again that in the fee schedule, some points are attributed to one unit of the medical service disaggregated item by item and one point is valued at 10 yen.

The most important fact derived from the table is that physicians seem to change the average quantity of medical services provided to patients after the reform. Patient-2's points per visit and expected fee per month increased from 368 to 622 and from 4293 yen to 7351 yen, respectively. The co-payment, however, changes very little, increasing from 506 to 535 yen. If a physician gives the same treatment to patient-2 as in the prereform period, the co-payment would decrease because the co-payment rate fell after the reform. The *t*-values to test the hypothesis of whether the prereform and postreform means of the variables are the same are also shown in the table. We find from the table that the *t*-values of points per visits and the expected fee per month are both positive and significant, while that of co-payment per visit is not significant at the 10% significance level. This implies that physicians changed the quantity of medical services, but tried to keep the co-payment constant in order to prevent patients from decreasing their number of visits. The number of visits per month by patient-2 increased from 1.23 to 1.29, which is not significant. On the other hand, patient-1's points per visit and expected fee per month did not change as much (decreasing from 1335 to 1306 points and from 19,426 yen to 19,716 yen, respectively), and their insignificant *t*-values imply that physicians did not change their medical services. The number of visits per month did not change either, although patient-1's co-payment per visit increased significantly from 458 yen to 1134 yen. From these facts, we find that the effects of the

[6] In general, the medical fees in Hospital A are higher than in Hospital B. This is because medical practice and medicine dispensation are not separated in Hospital A but are separated in Hospital B. The medical fees of a claim are then larger on average in Hospital A because they include the cost of prescribed medicine.

introduction of the proportional co-payment scheme are not symmetric for patient-1 and patient-2 of Hospital A. We discuss this point in the last paragraph of Section 5.

In Hospital B, however, the effects are symmetric, as we anticipated in the model presented in the previous section. The points per visit and expected fee per month for patient-1 significantly decreased from 1054 to 710 points and from 5380 yen to 3793 yen, respectively, while the points per visit and the fee for patient-2 significantly increased from 304 to 442 points and from 1898 yen to 2820 yen, respectively. The expected visits per month of patient-1 decreased from 0.69 to 0.65, while the visits of patient-2 increased from 0.63 to 0.68; both changes are insignificant. The co-payment per visit of patient-1 increased significantly from 497 yen to 590 yen, while that of patient-2 significantly decreased from 520 yen to 390 yen. This implies that physicians in Hospital B provide fewer medical services to patient-1 after the reform and more to patient-2[7].

A question then arises: how do physicians control the total medical fee? The answer is in Table 2: physicians change the quantities of medical services mainly with *laboratory tests*, in *diagnostic imaging*, or in *medication*, particularly for Hospital A. In general, there are two ways to change the services: one is to change the intensity of the service, and the other is to change the number of patients to whom the specific medical services are provided. We show two test statistics, one to test whether the pre- and postreform means of the variables are the same[8], while the other is to test whether the pre- and postreform ratios of patients to whom the specific medical services are provided to the population (nonzero ratio) are the same.

In Hospital A, the main sources of medical fees are *medication*, *laboratory tests*, and *diagnostic imaging*. For patient-1, physicians significantly decreased average *laboratory tests* from 228 to 191. The changes in the mean *medication* or *diagnostic imaging* are insignificant. The nonzero ratios of these three categories decreased significantly, which implies physicians in Hospital A provided these medical services to fewer patients after the reform. At the same time, as indicated by the zero-excluded *t*-

[7] We also calculated the asymptotic *t*-values of the hypothesis that the means of the two groups are the same when the population variances are different. The values are almost the same as those in Table 1.
[8] Note that the zero samples of each category, that is, patients to whom no service of the category is provided, are included when calculating the means in the table.

values, *medication* and *diagnostic imaging* fees increased significantly but *laboratory tests* decreased. With these facts in mind, we can argue that the typical physician in Hospital A provides *medication*, *laboratory tests*, or *diagnostic imaging* to fewer patients after the reform, while increasing the intensity of *medication* and *laboratory tests*. On the other hand, physicians significantly increased the average fees for patient-2 in these three categories, from 160 to 197 in *medication*, from 80 to 141 in *laboratory tests*, and from 24 to 118 in *diagnostic imaging*. The changes of nonzero ratios are insignificant. As for the nonzero samples, the intensities of the three categories significantly increased. This implies that physicians increased the intensity of these services only to those patients who received the same kind of services before.

In Hospital B, the main sources of medical fees are *laboratory tests* and *diagnostic imaging*. They significantly decreased for patient-1, while they significantly increased for patient-2. The zero ratios decreased significantly in both categories for patient-1 and in *laboratory tests* for patient-2. The ratio in *diagnostic imaging* of patient-2 decreased but not significantly. The intensities of the nonzero samples increased in the categories for both patient-1 and patient-2. These imply that the typical physician in Hospital B decreased the medical fees for patient-1 by providing *laboratory tests* or *diagnostic imaging* to fewer patients or by decreasing intensity, while increasing intensity for patient-2.

Figures 2 and 3 depict the cumulative distribution functions (CDFs) of *laboratory test* fees of patient-1 and the patient-2 in the prereform and postreform periods of Hospitals A and B. The CDF of patient-1 shifts upward after the reform, which implies that laboratory test fees became smaller, while that of patient-2 shifts downward, which implies that laboratory test fees became larger.

Note that *base fee*'s share to the total fee is not small and it also increased in the patient-1 and decreased in the patient-2 significantly both in Hospital A and in Hospital B. Although the reason for these significant changes is not clear[9], the amount of the

[9] There are two types of base fee: a fee for the initial visit and a fee for recurring visits. When patients visit a physician for an illness for the first time, they pay the former fee; when they visit again for the same illness, they pay the latter fee as the base fee. The initial-visit fee is nearly three times the repeat-visit fee. The point is that the physician decides whether a patient's visit is for the same illness as the previous visit or for a new illness. Changes in the base fee in both Hospital A and Hospital B may reflect manipulation of this decision.

changes is not large compared with the changes of other sources of medical fee so that it does not contribute much to the change in the total medical fee.

In summary, physicians in Hospital A and Hospital B behave as the model anticipated except for the case of patient-1 in Hospital A, in particular for *medication*.

4.2. Between-group differences

Although we find that the means of points per visit, expected fee per month, and provisions of some medical services changed significantly and adversely after the reform in both groups, patient-1 and patient-2, we also have to test if the opposite direction of change is statistically significant between the two groups. We take the differences in medical fees between the two periods of the patients belonging to the patient-1 group or to the patient-2 group, and then compare the distributions of the between-period fee-differences between the groups. If the directions of the two groups are significantly different, the CDF of the between-period fee-differences of patient-1 should be located on the left-hand side of that of patient-2; that is, the percentile points of the distribution of patient-1 are lower than those of patient-2.

Table 3 shows the descriptive statistics of the distribution in four important fee-related variables, points per visit, expected fee per month, and medical services, namely, *medication* and *laboratory tests* for Hospital A and *laboratory tests* and *diagnostic imaging* for Hospital B, and also shows the *t* statistics for the means and the confidence intervals of the medians to examine whether they differ between the patient-1 and patient-2 groups. We find that the mean and the percentile points, namely, 10%, 25%, median, 75%, and 90% points, of the between-period differences of patient-1 are smaller than those of patient-2, in both Hospital A and Hospital B, which implies that the CDF of patient-1 is located on the left-hand side of that of patient-2. These results reinforce the findings in Tables 1 and 2; that is, points per visit and medical services decreased in the patient-1 category but increased in the patient-2 category. This was associated with the changes of *laboratory tests* and/or *diagnostic imaging*. Note that the distribution of *medication* does not differ much so we cannot say whether *medication* is used to control the medical fees in Hospital A.

The *t* statistics, testing if the means of the two distributions are different, show that the differences of the means in the four variables are statistically significant. We also make 99% confidence intervals of the differences between the medians of the patient-1 and the patient-2 category using bootstrapping. Both the upper and lower bounds are positive except for the lower bound of the *medication* in Hospital A, which implies that the median of the distribution of patient-2 is larger than that of patient-1. This implies that physicians changed the quantities of medical services differently for patient-1 and patient-2 after the reform by controlling *laboratory tests* and/or *diagnostic imaging*.

4.3. Validity of the grouping

The results from Tables 1–3 may be criticized from a statistical viewpoint. We consider that patient-2 is characterized as a patient with a less serious disease and thus points per visit are relatively low, while patient-1 is diagnosed with a more serious disease and thus the points per visit are relatively high. This categorization may be criticized as follows. Even if there are differences in the severity of the diseases between patient-1 and patient-2, both patient groups need periodical *laboratory tests* or *diagnostic imaging*, for example once or twice a year. The patient with fewer points per visit before the reform does not need laboratory tests in that period and thus needs the tests in the next period, and vice versa. This is why the points per visit of patient-2 increased after the reform while those of patient-1 decreased.

More generally, if the pre- and postreform points per visit are positively correlated, it is well known that the regression coefficient of postreform points on prereform points should be less than one when they follow a normal distribution. The positive correlation is likely because most patients in this data set have a chronic disease, so the medical services provided to them do not change substantially. We may then fall into Galton's regression fallacy. The regression slope of the expectation of the difference between the pre- and postreform points per visit is negative on the prereform points per visit and the intercept is positive as long as the two distributions of the points per visit have nearly the same means and variances[10]. Thus, the points per visit of patients with lower medical fees increase after the reform, while those of patients with higher medical fees decrease. In general, the points per visit of patient-2 are lower than those of patient-1 so that we may misconstrue these effects as a physician's reaction against the reform.

To respond to this criticism, we compare the distribution of the between-period fee-differences of patient-1 and patient-2 based on the same fee bands in Table 4. In panel A of the table, we examine whether the distributions of patient-1 and patient-2 in the domain of fewer points per visit (from 100 to 1000 points) are the same, while in panel B we examine the distribution in the domain of more points per visit (over 1000 points). We employ five fee bands for panel A based on 20 percent interval percentiles of the prereform points per visit of the total number of patients (including both patient-1 and patient-2) who have between 100 and 1000 points per visit from both Hospital A and Hospital B, and for panel B based on the same percentiles of the total number of patients who have more than 1000 points per visit. In panel B, we compare the between-period fee-differences of patient-1 with the fee-differences between the first six months and the second six months of the prereform period of the total number of patients who had more than 1000 points in the first six months of the prereform period. This is because there are fewer patients in the patient-2 group who have more than 1000 points per visit.

We find in panel A that the between-period fee-differences of patient-2 are larger than those of patient-1 in every fee band in both Hospital A and Hospital B. This implies that the possible criticism is not valid because there would be no statistical difference between the distributions if it were valid. In the domain with more points per visit, that is, in Panel B, the absolute values of the means of fee-differences in patient-1 are larger than those of the prereform between-period fee-differences in every fee band in Hospital B. This implies that points for patient-1 patients decrease more than points for patients with the same number of points per visits in the first six month before the reform. In other words, fewer medical services are provided to patient-1 than to patients

[10] The expectation of the difference is expressed as $E\left[y-x\,|\,x\right]=m_y-\frac{\rho\sigma_y}{\sigma_x}m_x-\left(1-\frac{\rho\sigma_y}{\sigma_x}\right)x$, where x and y are the pre- and post-reform points per visit, m_x, m_y, σ_x and σ_y are their means and standard deviations, and ρ is the correlation coefficient.

with the same number of points per visit before the reform. These results answer any criticism and reinforce our argument that physicians will change their behavior in response to co-payment reform.

The exception is, however, patient-1 in the domain with more points per visit in Hospital A. The absolute values of the means of fee-differences in patient-1 are smaller in every fee band, which implies that physicians did not decrease the medical services as much as for ordinary patients with the same number of points per visit. This result corresponds to the findings in Tables 1 and 3. The important point, however, is that the distributions of the between-period fee-differences of patient-1 are different from the prereform between-period fee-differences, which implies that decreases in the number of points per visit are not caused by Galton's regression fallacy or by periodically conducted laboratory tests. Physicians in Hospital A appear to try to keep the fee per visit nearly the same as before the reform for patients with more points per visit. This is possible if the demand for the services provided by the Hospital A is inelastic.

In summary, we conclude that the between-period fee-differences of patient-1 and patient-2 are not caused by ordinary changes, as Galton's regression fallacy predicts, or the periodical changes of treatments, but are caused by changes in physician behavior.

4.4. Tests according to disease

The data set we used contains information about the each patient's diseases. This allows us to examine whether the results above hold true for four representative diseases in the elderly, namely, cataract and related diagnoses, gastric ulcer and the related diagnoses, hypertension, and diabetes mellitus. We pick up patients who have claims on which at least one of these diagnoses is listed. Note that, as elderly patients could have two or more of the diagnoses listed above, there is some overlap of patients in the diagnosis data sets, but the number is not large.

Table 5 summarizes the statistics listed in Tables 1 and 2 of points per visit, expected fee per month, *medication*, *laboratory tests*, and *diagnostic imaging*. Almost the same findings discussed earlier hold for these four diagnoses: postreform, points per visit increase for patient-2 associated with the increase of *laboratory tests* in Hospital A, while the points per visit increase (decrease) for patient-2 (patient-1) associated with the increase (decrease) of *laboratory tests* and/or *diagnostic imaging* in Hospital B.

5. Conclusion

In this paper, we investigate how physicians change the quantity of medical services to patients in response to reform of the co-payment scheme for the elderly from a fixed to a proportional co-payment system. We propose a physician–patient interaction model where the physician decides the quantity of medical services first and then the patient decides the number of visits. We also examine empirically whether physicians change the quantities of medical services associated with the co-payment scheme, and if so, in which kind of services. We find that physicians provide more services to patients whose co-payment would decrease if the services were the same as before the reform and fewer services to patients whose co-payment would increase, by changing the quantities of *laboratory tests* and/or *diagnostic imaging*.

This paper's contributions are twofold: one is to formulate a model incorporating the interaction between physicians and elderly patients based on the Japanese health care system, and the other is to empirically examine the validity of the model by reviewing whether the changes in the quantity of medical services that physicians provide is the same as the model predicts. Many studies examine physician behavior from the viewpoint of demand inducement based on a fee-for-service reimbursement scheme or study patient behavior from a moral hazard viewpoint. Only a few discuss the physician–patient interaction, including Ma and McGuire (1997) and Lien et al. (2004), which empirically examines which type of interaction is most effective—rationing, effort or persuasion—based on the interaction mode. In our paper, the predicted results derived from our interaction model are supported by the data.

A few questions arise, however, concerning the data. For example, why did Hospital A not change the quantity of medical services to patient-1, whose co-payment rate rose after the reform, while changing the quantity provided to patient-2, whose co-payment rate fell after the reform? On the other hand, Hospital B decreased the quantity of services provided to patient-1, while increasing the quantity to patient-2. The two hospitals have very similar attributes, that is, they have nearly the same number of beds, doctors and specialties so it is expected that they would also have similar behavior. The difference in behavior between the two hospitals may depend on the demand elasticity to the co-payment of patients. We assume elastic demand for medical services in our model. However, the demand may be inelastic in Hospital A because there may be excellent physicians in the hospital or there may be only a few competitors near the hospital. Accordingly, Hospital A does not need to decrease medical services to patient-1 to prevent them from moving to a competitor. A future research project could consider how hospitals' changes to the quantity of medical services correspond to the competitive environment.

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Appendix A:

In this appendix, we present details of how we obtain the marginal rates of substitution of the fixed co-payment and the proportional co-payment schemes in Section 2. In the case of the fixed co-payment, the marginal payoffs with respect to x_1 and x_2 are

$$\frac{\partial \Pi^f}{\partial x_1} = \left[\frac{(1-\delta) y}{f+t} - \frac{\delta h}{\theta_2 x_2} \right] \eta_1 ,$$

and

$$\frac{\partial \Pi^f}{\partial x_2} = \left[\frac{(1-\delta) y}{f+t} - \frac{\delta h}{\theta_2 x_2} \right] \eta_2 + \frac{\delta h}{\theta_2} \cdot \frac{1}{x_2^2} \left(\eta_1 x_1 + \eta_2 x_2 \right) .$$

Thus the marginal rate of substitution is

$$-\left. \frac{dx_1}{dx_2} \right|_{\Pi^f = const} = \frac{\partial \Pi^f / \partial x_2}{\partial \Pi^f / \partial x_1} = \frac{\eta_2}{\eta_1} + \frac{1}{\partial \Pi^f / \partial x_1} \frac{\delta h}{\theta_2} \cdot \frac{1}{x_2^2} \left(\eta_1 x_1 + \eta_2 x_2 \right) .$$

In the case of the proportional co-payment, the marginal payoffs are

$$\frac{\partial \Pi^P}{\partial x_2} = \left[\frac{(1-\delta) yt}{\left(p\boldsymbol{\varphi}'\mathbf{x} + t \right)^2} - \frac{\delta h}{\theta_2 x_2} \right] \eta_2 + \frac{\delta h}{\theta_2} \cdot \frac{1}{x_2^2} \left(\eta_1 x_1 + \eta_2 x_2 \right) ,$$

and

$$\frac{\partial \Pi^P}{\partial x_1} = -\frac{(1-\delta) y \left[p x_2 \left(\varphi_1 \eta_2 - \varphi_2 \eta_1 \right) - t \eta_1 \right]}{\left(p\boldsymbol{\varphi}'\mathbf{x} + t \right)^2} - \frac{\delta h \eta_1}{\theta_2 x_2} = \left[\frac{(1-\delta) yt}{\left(p\boldsymbol{\varphi}'\mathbf{x} + t \right)^2} - \frac{\delta h}{\theta_2 x_2} \right] \eta_1 .$$

In the second equation, we used the assumption that the margin rates of the two medical services are the same, namely, $\frac{\eta_1}{\varphi_1} = \frac{\eta_2}{\varphi_2}$. Then, the marginal rate of substitution is obtained as

$$-\left. \frac{dx_1}{dx_2} \right|_{\Pi^P = const} = \frac{\partial \Pi^P / \partial x_2}{\partial \Pi^P / \partial x_1} = \frac{\eta_2}{\eta_1} + \frac{1}{\partial \Pi^P / \partial x_1} \frac{\delta h}{\theta_2} \cdot \frac{1}{x_2^2} \left(\eta_1 x_1 + \eta_2 x_2 \right) .$$

Figure 1: Changes in quantities of medical services

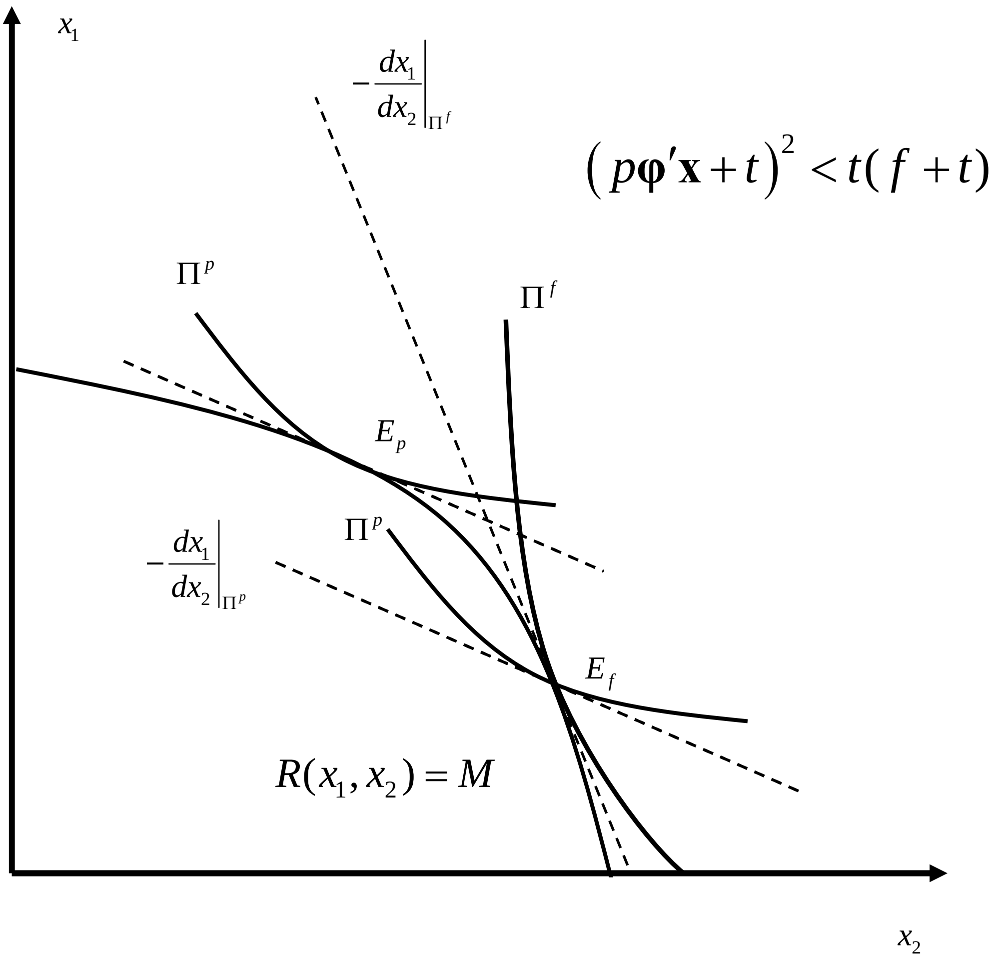
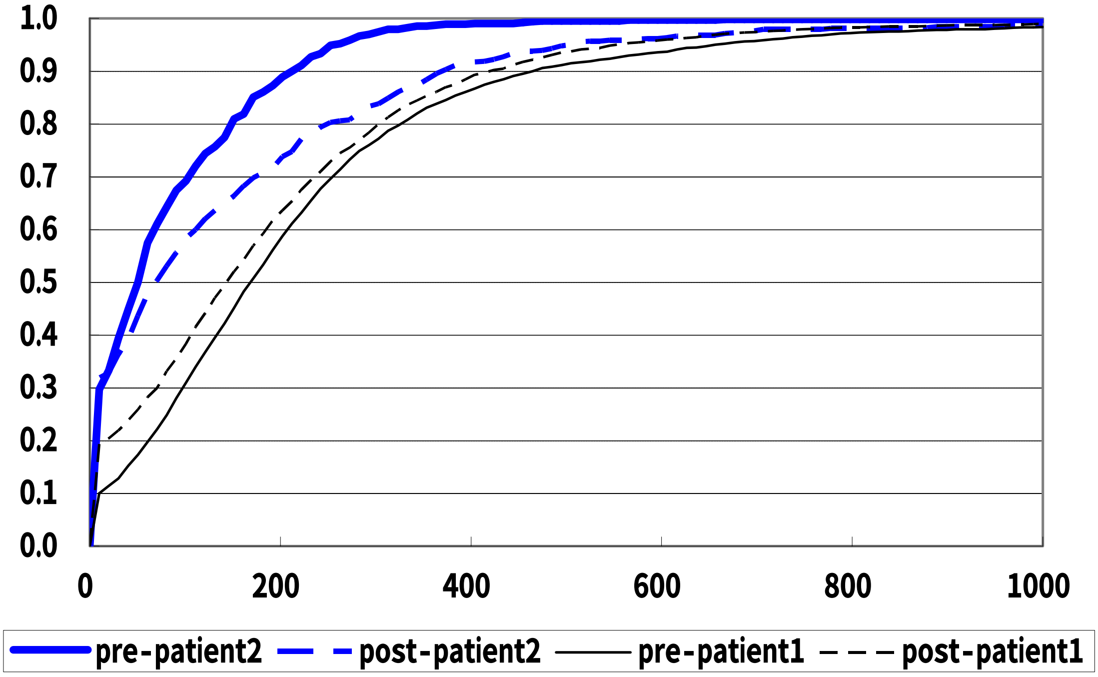
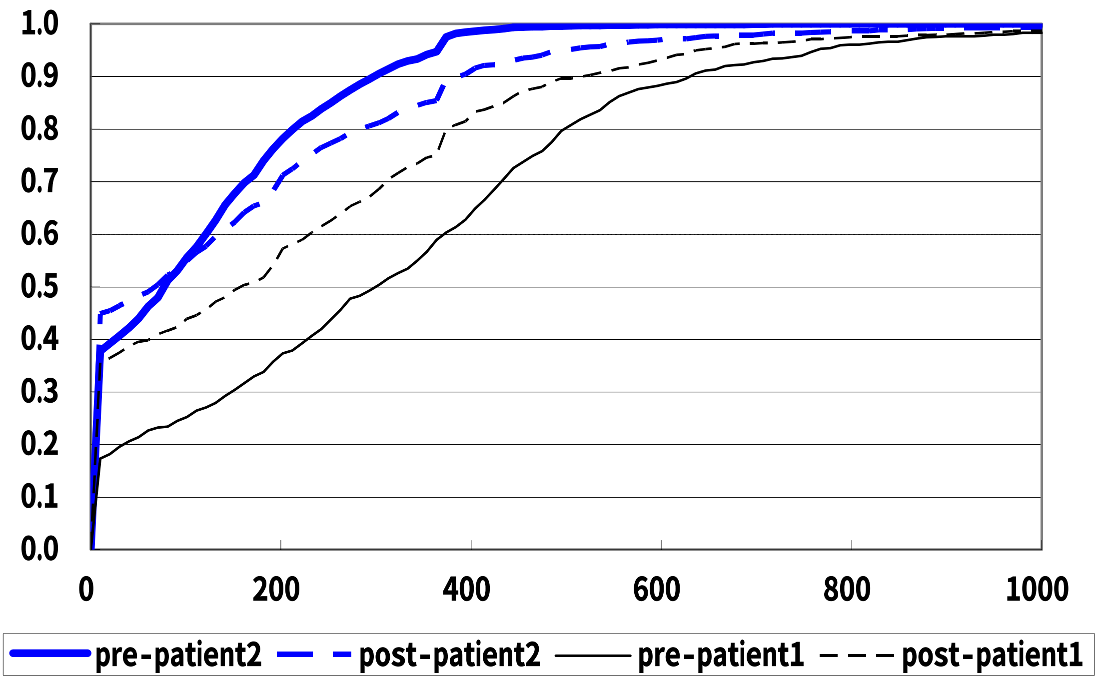


Figure 2: CDFs of laboratory test fee in Hospital A in pre- and postreform periods



Note: The legends, pre-patient1, post-patient1, pre-patient2 and post-patient1 means laboratory fee of patient-1 in prereform period, that of patient-1 in postreform period, that of patient-2 in prereform period and that of patient 2 in postreform period, respectively.

Figure 3: CDFs of laboratory test fee in Hospital B in pre- and postreform periods



Note: The legends, pre-patient1, post-patient1, pre-patient2 and post-patient1 means laboratory fee of patient-1 in prereform period, that of patient-1 in postreform period, that of patient-2 in prereform period and that of patient 2 in postreform period, respectively.

Table 1: Between-period Changes in Visits, Fees, Copayment and Copayment Rate

		No. of Sample	No. of claims	No. of claims per month	No. of visits per claim	Points per visit	Copayment per visit	Expected visits per month	Expected fee per month (yen)	copayment rate (%)
Hospital A										
				copayment rate rose			(patient-1)			
mean	pre	3621	8.56	0.71	2.18	1335	458	1.64	19,426	4.66
	post		4.52	0.75	2.07	1306	1134	1.65	19,716	9.51
s.d.	pre		3.90	0.32	1.61	1128	102	1.67	21,001	2.23
	post		1.80	0.30	1.63	1233	737	1.68	21,979	1.45
t value				5.56	-2.97	-1.04	54.60	0.27	0.57	
				copayment rate fell			(patient-2)			
mean	pre	690	7.68	0.64	1.76	368	506	1.23	4,293	16.36
	post		4.00	0.67	1.82	622	535	1.29	7,351	9.65
s.d.	pre		4.01	0.33	1.17	141	58	1.25	4,263	10.26
	post		1.87	0.31	1.25	781	444	1.24	11,508	1.29
t value				1.53	0.93	8.40	1.73	0.95	6.55	
Hospital B										
				copayment rate rose			(patient-1)			
mean	pre	932	3.10	0.26	2.48	1054	497	0.69	5,380	6.61
	post		1.84	0.31	1.98	710	590	0.65	3,793	9.69
s.d.	pre		2.08	0.17	2.67	1249	88	1.04	8,016	2.48
	post		0.98	0.16	1.96	1076	515	0.91	6,351	1.62
t value				6.11	-4.52	-6.37	5.46	-0.70	-4.74	
				copayment rate fell			(patient-2)			
mean	pre	2179	4.16	0.35	1.83	303	520	0.63	1,898	21.17
	post		2.21	0.37	1.83	442	390	0.68	2,820	9.71
s.d.	pre		2.34	0.20	1.38	152	46	0.57	1,817	10.46
	post		1.19	0.20	1.63	709	329	0.71	4,275	1.07
t value				3.66	0.14	8.98	-18.35	2.41	9.27	

Note: The patient-1 denotes the patients whose copayment rates rose after the reform, while the patient-2 denotes patinets whose copayment rates fell after the reform.

Table 2: Between-period Changes in Medical Fee by Fee Categories

		Base	Consultation	Doctor-visit	Medication	Injection	Physical therapy	Operation	Laboratory test	Diagnostic Imaging	Others
Hospital A											
					copayment rate rose		(patient-1)				
mean	pre	74	29	98	648	86	6	18	228	136	10
	post	72	30	107	664	88	5	10	191	128	11
s.d.	pre	44	63	691	574	549	44	144	270	332	48
	post	43	61	764	618	576	25	98	209	349	49
t value		-2.45	0.53	0.55	1.20	0.12	-2.25	-2.64	-6.57	-1.05	0.25
t value (zeros excluded)		-2.14	1.43	0.59	2.61	2.49	2.74	0.20	-2.68	4.93	2.44
Nonzero ratio	pre	1.00	0.94	0.04	0.94	0.23	0.36	0.08	0.91	0.68	0.08
	post	0.99	0.90	0.04	0.92	0.16	0.17	0.04	0.81	0.48	0.07
t value		-2.49	-6.17	0.18	-4.30	-7.24	-18.13	-6.30	-11.76	-17.68	-1.77
					copayment rate fell		(patient-2)				
mean	pre	75	10	1	160	3	7	1	80	24	8
	post	81	11	19	197	9	7	30	141	118	9
s.d.	pre	45	29	10	120	16	28	11	99	70	37
	post	55	30	325	226	93	31	243	197	492	42
t value		2.30	1.22	1.45	3.84	1.73	-0.20	3.13	7.21	4.98	0.22
t value (zeros excluded)		2.59	1.31	1.56	3.98	1.68	2.29	3.69	8.53	5.23	0.52
Nonzero ratio	pre	0.99	0.76	0.00	0.86	0.06	0.29	0.02	0.72	0.34	0.08
	post	0.98	0.75	0.01	0.87	0.07	0.16	0.04	0.70	0.35	0.08
t value		-1.42	-0.31	1.27	0.48	0.85	-5.68	1.97	-0.83	0.34	-0.20
Hospital B											
					copayment rate rose		(patient-1)				
mean	pre	117	20	173	3	26	4	124	319	209	60
	post	94	21	163	2	17	2	19	211	118	64
s.d.	pre	103	63	1020	19	101	18	776	279	403	44
	post	76	74	1009	27	73	13	149	239	346	46
t value		-5.60	0.16	-0.20	-0.57	-2.17	-3.17	-4.04	-8.98	-5.27	2.05
t value (zeros excluded)		-2.49	-6.17	0.18	-4.30	-7.24	-18.13	-6.30	-11.76	-17.68	-1.77
Nonzero ratio	pre	1.00	0.15	0.08	0.06	0.19	0.18	0.14	0.83	0.61	0.84
	post	1.00	0.11	0.07	0.03	0.11	0.05	0.07	0.64	0.29	0.81
t value		.	-2.74	-0.45	-2.33	-4.86	-9.02	-4.84	-9.66	-14.70	-1.22
					copayment rate fell		(patient-2)				
mean	pre	73	8	0	1	7	1	4	110	24	75
	post	81	13	6	2	9	5	40	146	67	73
s.d.	pre	27	32	8	4	28	6	79	122	56	29
	post	57	49	112	44	50	124	609	204	206	35
t value		6.16	3.75	2.14	1.93	2.27	1.33	2.78	6.92	9.42	-1.85
t value (zeros excluded)		-2.49	-6.17	0.18	-4.30	-7.24	-18.13	-6.30	-11.76	-17.68	-1.77
Nonzero ratio	pre	1.00	0.10	0.00	0.03	0.12	0.08	0.04	0.63	0.29	0.95
	post	1.00	0.10	0.01	0.03	0.10	0.04	0.04	0.55	0.27	0.93
t value		.	0.15	1.28	-0.54	-2.34	-5.29	0.87	-5.35	-1.11	-2.98

Note: The patient-1 denotes the patients whose copayment rates rose after the reform, while the patient-2 denotes patinets whose copayment rates fell after the reform.

Table 3: Tests of Between-group Differences of Between-period Fee-differences

	Hospital A				Hospital B			
	Points per visit	Expected fee per month (yen)	Medication	Laboratory test	Points per visit	Expected fee per month (yen)	Laboratory test	Diagnostic Imaging
			copayment rate rose		(patient-1)			
Mean	-29	290	17	-37	-344	-1587	-108	-92
10%	-592	-10328	-288	-234	-896	-6212	-466	-419
25%	-232	-4269	-95	-95	-524	-2794	-266	-151
Median	-10	-283	0	-8	-244	-903	-56	0
75%	182	4251	120	53	-8	790	12	0
90%	490	11349	332	166	278	3007	185	111
s.d.	734	13259	390	273	959	6175	310	397
			copayment rate fell		(patient-2)			
Mean	254	3056	37	61	139	922	35	43
10%	-83	-1910	-70	-71	-188	-1655	-155	-55
25%	-13	-437	-15	-11	-59	-597	-50	0
Median	61	518	1	0	12	205	0	0
75%	253	3328	44	88	184	1518	89	0
90%	651	9211	145	243	459	3810	247	148
s.d.	725	9981	196	186	652	4042	199	206
t statistics	9.37	6.30	2.09	11.63	14.07	11.41	13.02	9.82
99% confidence interval of the difference between the medians of the patient-1and the patient-2								
upper bound	101.3	1217.9	2.4	16.4	302.7	1351.7	90.5	19.0
lower bound	48.6	450.8	-2.7	2.2	218.2	810.8	32.1	0.0

Note: The s.d. denotes the standard deviation. The t statistics are for testing if the means of the variables of the patient-1 and the patient-2 categories are the same.

Table 4: Validity Test of the Grouping

	Hospital A			Hospital B	
	Panel A				
Lower Point-Per-Visit Domain (100-1000 points)	**Means of the between-period fee differences in Patient-2**	**Means of the between-period fee differences in Patient-1**		**Means of the between-period fee differences in Patient-2**	**Means of the between-period fee differences in Patient-1**
Fee Band (points)			**Fee Band (points)**		
I (100 - 407)	159	93	**I (100-180)**	191	81
II (408 - 560)	191	107	**Ⅱ (181-302)**	148	43
III (561 - 694)	1575	61	**III(303-412)**	126	-20
IV (695 - 834)	1098	34	**IV(413-553)**	11	-70
V (835 - 1000)	3031	51	**V(554-1000)**	1065	-179
mean	233	59		134	-148
median	60	14		23	-187
s.d.	685	346		542	366
t value	6.32			15.42	
	Panel B				
Higher Point-Per-Visit Domain (over-1000 points)	**Means of the pre-reform between-period fee differences**	**Means of the between-period fee differences in Patient-1**		**Means of the pre-reform between-period fee differences**	**Means of the between-period fee differences in Patient-1**
Fee Band (points)			**Fee Band (points)**		
I (1001 - 1145)	-35	48	**I (1001-1109)**	-10	-386
II (1146 - 1354)	-99	-11	**II (1110-1298)**	-60	-411
III (1355 - 1644)	-128	-83	**III(1299-1614)**	-124	-571
IV (1645 - 2271)	-255	-108	**IV(1615-2646)**	-288	-1090
V (2272 - 12608)	-619	-403	**V(2646-14550)**	-711	-2246
mean	-235	-111		-235	-939
median	-171	-77		-171	-747
s.d.	890	960		890	1682
t value	-4.02			6.26	

Note 1: We employ five fee bands for panel A based on 20 percent interval percentiles of the prereform points per visit of the total number of patients (including both patient-1 and patient-2) who have between 100 and 1000 points per visit from both Hospital A and Hospital B, and for panel B based on the same percentiles of the total number of patients who have more than 1000 points per visit.

Note 2: In panel B, we compare the between-period fee-differences of patient-1 with the fee-differences between the first six months and the second six months of the prereform period of the total number of patients who had more than 1000 points in the first six months of the prereform period.

Table 5: Tests According to Disease

		Hospital A				Hospital B			
		Points per visit	Expected fee per month (yen)	Medication	Laboratory test	Points per visit	Expected fee per month (yen)	Laboratory test	Diagnostic Imaging
Cataract and the related diagnoses									
copayment rate rose (patient-1)									
Between-periods change									
number of sample			917				204		
mean	pre	1060	20761	568	201	904	8218	374	144
	post	1067	20036	591	191	606	6045	308	49
t value		0.16	-0.73	0.99	-1.32	-4.85	-2.45	-3.23	-4.21
Between-period fee difference									
mean		6.44	-724.73	22.50	-9.27	-297.75	-2173.33	-66.26	-95.54
median		1.02	-656.25	3.60	-2.73	-174.71	-1154.17	-39.33	-24.00
copayment rate fell (patient-2)									
Between-periods change									
number of sample			200				258		
mean	pre	822	21612	446	151	380	4072	197	22
	post	942	20651	523	151	510	6098	231	45
t value		3.73	3.36	2.11	4.08	4.51	3.72	2.77	2.69
Between-period fee difference									
mean		245.07	3277.67	36.64	52.85	130.36	2025.79	33.75	23.34
median		53.62	335.00	1.43	21.55	31.33	300.00	9.27	9.27
t value		3.72	4.59	0.77	5.01	7.33	5.21	5.48	5.58
Gastric Ulcer and the related diagnoses									
copayment rate rose (patient-1)									
Between-periods change									
number of sample			1030				45		
mean	pre	1430	25086	759	220	1057	9740	320	292
	post	1438	24336	789	189	864	9298	227	219
t value		0.15	-0.73	1.06	-3.23	-0.78	-0.15	-1.46	-0.65
Between-period fee difference									
mean		8.51	-749.93	30.83	-31.21	-193.53	-442.50	-93.32	-72.17
median		-8.99	-979.17	5.87	-14.97	-229.29	-1866.67	-74.10	-57.15
copayment rate fell (patient-2)									
Between-periods change									
number of sample			70				144		
mean	pre	394	6540	193	73	301	3673	103	31
	post	824	13168	247	168	453	5289	156	63
t value		3.40	3.07	1.51	2.69	3.34	3.34	3.17	3.05
Between-period fee difference									
mean		429.41	6627.44	54.17	95.38	152.68	1615.64	52.69	32.40
median		108.02	1428.33	0.00	0.00	47.08	711.67	0.00	0.00
t value		3.84	3.93	0.83	3.84	3.79	1.94	2.42	1.83

Table 5: Tests According to Disease (continued)

		Hospital A				Hospital B			
		Points per visit	Expected fee per month (yen)	Medication	Laboratory test	Points per visit	Expected fee per month (yen)	Laboratory test	Diagnostic Imaging
Hypertension									
copayment rate rose (patient-1)									
Between-periods change									
number of sample			1036				155		
mean	pre	1276	22764	782	187	994	11984	244	198
	post	1289	22834	810	175	712	8658	184	115
t value		0.36	0.09	1.18	-1.64	-2.04	-2.01	-2.68	-2.63
Between-period fee difference									
mean		13.36	70.79	28.37	-11.78	-282.04	-3326.35	-59.44	-83.09
median		0.87	-602.5	1.28	-3.97	-148.09	-1887.08	-19.62	-30.41
copayment rate fell (patient-2)									
Between-periods change									
number of sample			129				503		
mean	pre	391	6745	204	78	308	4549	107	34
	post	694	12294	265	132	385	5684	124	64
t value		3.02	3.24	1.81	2.90	3.02	3.24	1.81	2.90
Between-period fee difference									
mean		302.68	5548.95	60.96	53.40	77.47	1135.46	17.23	30.40
median		66.49	1684.58	1.75	4.84	19.99	315.42	0.00	0.00
t value		3.10	3.76	1.06	4.48	4.00	4.64	3.81	4.43
Diabetes Mellites									
copayment rate rose (patient-1)									
Between-periods change									
number of sample			1052				96		
mean	pre	1525	25368	809	236	858	12730	289	90
	post	1517	25739	831	206	734	10045	274	65
t value		-0.13	0.35	0.76	-2.96	-1.48	-1.74	-0.62	-1.07
Between-period fee difference									
mean		-7.70	371.04	21.67	-30.54	-124.02	-2685.31	-14.42	-24.14
median		8.76	-498.33	1.83	-13.33	-75.63	-1591.67	-7.27	-7.03
copayment rate fell (patient-2)									
Between-periods change									
number of sample			81				153		
mean	pre	381	5839	154	101	364	5277	182	23
	post	705	11219	236	219	512	7024	204	56
t value		4.33	2.66	1.79	3.75	3.02	3.19	1.58	1.95
Between-period fee difference									
mean		324.04	5380.21	82.05	117.81	148.40	1746.48	22.40	33.44
median		109.98	1443.75	0.25	21.38	23.23	514.17	9.90	0.00
t value		4.66	2.69	1.36	5.04	3.41	3.27	1.91	2.73