

## Intrinsic Motivation of Physicians

**Makoto Kakinaka**  
International University of Japan

and

**Ryuta Ray Kato**  
International University of Japan

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Graduate School of International Relations  
International University of Japan

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## **Intrinsic Motivation of Physicians<sup>\*</sup>**

**Makoto Kakinaka**

Assistant Professor

Graduate School of International Relations, International University of Japan

**Ryuta Ray Kato**

Associate Professor

Graduate School of International Relations, International University of Japan

### **Abstract**

By incorporating the concept of intrinsic motivation of physicians into a theoretical framework, this paper examines the possible existence of multiple equilibria in which hospitals differ only in terms of the work attitude of physicians, who are homogenous in all other aspects, including benevolence in their concern for their patients. Our results offer a theoretical understanding of a phenomenon observed frequently in any society, namely that of the existence of hospitals with more or less similar management environment, but with significant differences in the work attitude of physicians and therefore medical treatments provided to patients.

**Key Words:** physician, intrinsic motivation, multiple equilibria, health care provider

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# 1 Introduction

It is often observed in real economies that some hospitals are more popular than others, even though we cannot find any substantial differences in the circumstances surrounding them. In popular hospitals patients usually expect to find not only better quality of services, but also more dedicated staff and physicians than in less popular hospitals. This paper presents a theoretical framework to describe such observable phenomenon by illustrating the possible existence of multiple equilibria in which hospitals differ only in terms of the work attitude of physicians, who are homogenous in all other aspects, including benevolence in their concern for their patients.

In recent research, attention has been paid to the difference between private and public hospitals. Simoens and Giuffridia (2004) observe that the difference between private and public hospitals in OECD countries is associated with that in the payment methods, such as fee-for-serve, capitation and salary systems. By categorizing hospitals based on the difference in the ownership structure, the theoretical framework of Wright (2007) shows that a profit maximizing private hospital optimally uses a fee-for-service or fixed salary method to employ physicians, while a benevolent public hospital uses a fixed salary payment method. Wright (2007) also points out by citing Duggan (2000) that the link between the behavioral difference between hospitals and the ownership structure might be rather weak.

Nevertheless, it is true that some hospitals are more popular than others among both private and public hospitals. Ever since Arrow (1963) considered benevolence or the ethical behavior of physicians as one of important elements, the efficiency-selection literature has shown time and time again that the heterogeneity in the benevolence of health care providers or physicians in their concern for their patients plays a vital role. Wright (2007) presents that the optimal payment method differs, depending on the degree of the physicians' benevolence in caring for their patients. Ellis and McGuire (1986) show in their seminal paper that a mixed payment system achieves the first best solution, and their result also depends on the parameter value of benevolence.

The literature has been expanded by incorporating the demand side, information asymmetry, and competition among care providers (see, e.g., Ellis and McGuire (1990), Glazer and McGuire (1994), Ma and McGuire (1997), Ellis (1998), and Chalkley and Malcomson (1998)), and the degree of benevolence seems to be crucial in their results. Apart from the efficiency-selection literature, benevolence or the ethical behavior of individuals in the health care system has recently been discussed, but in a different aspect. Assuming ex-ante heterogeneity in the distribution of nurses in terms of vocation, Heyes (2005) discusses that an increase in the wage of nurses would result in a relative decrease in the number of nurses with ‘vocation’, thus a relative increase in the number of ‘bad’ nurses, since the increase in the wage attracts more ‘bad’ nurses who are interested in money rather than having a sense of vocation about work.<sup>1</sup>

How this paper differs from past work is that no ex-ante heterogeneity of physicians is assumed, i.e. benevolence is identical for all physicians. Moreover, instead of considering any differences in the ownership structure or payment methods, we assume that all hospitals simply employ physicians through a fixed payment scheme so that there is no incentive to work harder in order to earn more. Even under these circumstances, this study will present substantial differences between hospitals by exploring the possibility of multiple equilibria: in one equilibrium there is a hospital where the positive work attitude of the physicians is attracting more patients; and in the other there is a hospital where the work attitude of the physicians is less positive, which attracts less patients. In the terms of vocation, two different types of hospitals could exist: those with physicians with a sense of vocation and those with physicians without vocation.

The key assumption to generate multiple equilibria is that physicians take into account behaviors of other physicians within the hospital. Being the same as typical workers in other working environments, physicians are concerned about their reputation or their relative position in comparison with others. This is captured by ‘intrinsic motivation’ in this

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<sup>1</sup>Taylor (2007) evaluates the work of Heyes (2005) in welfare.

study. Physicians may be more motivated by the idea of intrinsic rewards such as pride or self respect, rather than by extrinsic rewards or financial benefits such as salary which are assumed in standard economic theories. Some researches, such as Frey (1993) and Frey and Oberholzer-Gee (1997), have claimed that human behavior is determined by the interplay between extrinsic and intrinsic motivation. Although various forms of intrinsic motivation could exist, we only focus on the intrinsic motivation associated with ‘mutual interactions’ with others, such as the process to obtain ideas of fairness or a reputation.<sup>2</sup> Actions of other physicians or outcomes of actions, which are easily observable, would often affect each physician’s action through a change in intrinsic motivation.

The concept of mutual interactions as intrinsic motivation is not new in the context of economic theory.<sup>3</sup> Many models of social interactions have been developed in the context of social norms and conformity (see e.g. Lindbeck (1997) for social norms and Bernheim (1994) for conformity). Social motivation has also been modeled in the discussions of voluntary cooperation or voluntary contributions to public goods (see e.g. Hollander (1990) and Rege (2004)) and of peer pressure and labor incentives (see e.g. Kandel and Lazear (1992) and Barron and Gjerde (1997)).<sup>4</sup> To characterize physicians’ behavior within a hospital, we explicitly incorporate intrinsic motivation into the standard model. To our best knowledge, there is no analytical work on physicians’ behaviors with mutual interactions.

We consider the rational behavior of physicians who have already been employed by a single hospital, so that we neither explore the choice of physicians by hospitals nor physicians’ choice of hospitals. A payment scheme is assumed to be based on a fixed salary method, which may be typical for many public hospitals, particularly in rural areas, as mentioned in Simoens and Giuffridia (2004). Intrinsic motivation is captured by the assumption that, in addition

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<sup>2</sup>This type of intrinsic motivation would be in accordance with Coleman (1990) in that social norm enforced by social sanctions takes the form of approval or disapproval from people. Another possible approach to capture intrinsic motivation may include an introduction of ‘vocation’ which has been discussed recently in the context of labor market for nurses (see, e.g., Heyes (2005) and Taylor (2007)).

<sup>3</sup>Many studies in the field of management science have also developed related models in the context of good soldier syndrome or organization citizenship behavior (see e.g. Bateman and Organ (1983) and Turnipseed (2002)).

<sup>4</sup>See also Manski (2000) for the discussion on social interactions.

to working hours and consumption, each physician's preference also depends on the relative health level of her own patients in comparison with those of other physicians' patients within the same hospital.<sup>5</sup> Specifically each physician is assumed to have an incentive to improve the health of her own patients relative to those of patients treated by other physicians.

We also assume that a mass of physicians is employed to conceptualize a society of physicians within the hospital, where the influential power or ability of each physician is too small to affect the average health level of all patients, i.e. the health of patients treated by other physicians within the same hospital is completely external to all physicians when they make a decision. We will then derive an equilibrium outcome within the hospital by introducing the concept of a fulfilled expectation equilibrium, where conjectures of all physicians in terms of the average health level coincide with the actual average health level. This outcome is considered as an equilibrium outcome of the supply-side of medical services, since the number of patients is taken as given at this stage.

To pay attention to the role of physicians' intrinsic motivation, we simply consider a situation where the number of patients treated in a hospital depends only on the average health level of its patients, which can be considered as the reputation of the hospital. The amount of medical services given to a patient is measured by the amount of time spent by each physician on her patient, which is determined solely by the physician. The assumption that all patients act passively with physicians' strong bilateral power could be regarded as an extreme case of physician-induced demand first studied by Evans (1974)<sup>6</sup>, or we simply assume that all patients are fully insured so that patients are willing to accept all medical treatments suggested by their physicians. With these assumptions we will then derive a social equilibrium, where the number of patients treated in a hospital is determined endogenously.

Our results show that a social equilibrium outcome depends on the number of physicians employed in the hospital. In particular, the model presents a possibility of the presence

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<sup>5</sup>This assumption is similar to Kandel and Lazear (1992).

<sup>6</sup>The discussion of physician-induced demand has been one of the important topics in the field of health economics. See McGuire (2000) for a review of physician-induced demand.

of two social equilibria. In one social equilibrium, there is a hospital with physicians with long working hours, achieving higher health levels in patients. In the other, there is a hospital with physicians with less working hours, not being able to achieve as high health levels. In the former equilibrium the endogenously determined number of patients is larger than that in the latter. Intrinsic motivation of physicians contributes to a possibility of the presence of multiple social equilibria. In the former social equilibrium, every physician works longer hours because others do so, whereas in the latter every physician does not work long hours, because nobody does so. This multiplicity is consistent with observations that a collective action is sometimes successful but sometimes not, as discussed in Ostrom (1990) and Rege (2004). Our results also provide a possible explanation for the observable phenomenon of there being a significant difference in the work attitudes of physicians and medical treatments among different private/public hospitals, even though each their own management environment seems almost identical.

The remainder of this paper consists of three sections. In the next two sections we will outline and explore the model of the behavioral decision problem of physicians with intrinsic motivation within a single hospital. After discussing the physicians' optimal behaviors, we will attempt to explain how the patients' health levels and the physicians' work attitude are determined endogenously in a hospital by introducing the concept of a fulfilled expectations equilibrium to mutual interactions among physicians. We will then characterize a social equilibrium outcome by incorporating the demand side or the patients' behaviors, followed by a presentation of our results, which will be explored intuitively. The plausibility of multiple equilibria will also be discussed. In the final section, we will conclude our paper.

## 2 The Model

We consider a simple model of medical services, which are supplied by homogeneous physicians employed in a single hospital and are demanded by potential patients in a society who

are also homogeneous. We assume that the health level of patients can be indexed by a measure, and the average of health levels of all patients who have been treated in the hospital,  $\bar{H}$ , is observable to all agents.<sup>7</sup>  $\bar{H}$  is considered as the reputation of the hospital in this paper. We also assume that the total number of patients treated in the hospital is simply the function of the reputation of the hospital,  $\bar{H}$ , and the total number (mass) of patients treated in the hospital,  $N$ , is given by:

$$N = D(\bar{H}),$$

where the function  $D$  is increasing and strictly concave with  $\lim_{\bar{H} \rightarrow \infty} D(\bar{H}) = \bar{N} > 0$ . If the average health level of the hospital increases, then the total number of patients treated in the hospital increases, but its marginal increment is diminishing. Although we admit that the total number of patients (or demand for medical services) generally depends on various factors such as the location of the hospital, we only focus on a situation where the reputation of the hospital associated with the average health level is only crucial in determining the total number of patients. Since it seems impossible for potential patients to know the health of each patient treated in the hospital, we simply assume that potential patients use the average health level of all patients treated in the hospital as the information on the hospital, which is the reputation of the hospital.

Faced with  $N$  patients, the hospital employs  $a$  (mass of) physicians, which is exogenously given. Each physician has to treat  $n \equiv N/a$  (mass of) patients equally. In this study, we neither explore the choice of physicians by hospitals nor physicians' choice of hospitals. We also assume that all patients are fully insured so that patients are willing to accept all medical treatments suggested by their physicians, and conventional principal-agent problems between the physician and the patient as well as those between the hospital manager and the physician are out of our scope.

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<sup>7</sup>We assume in this paper that patients' health levels can be indexed although it is in general difficult to measure them. In our model, patients' health levels might also be reinterpreted as the degrees of patients' satisfaction for medical treatments.



Each physician has identical preference, which is described by the following additive form:

$$u = V(l, y) + M, \tag{1}$$

where  $l$  and  $y$  denote her working hours and her own consumption, respectively. Physician's working hours  $l$  are expressed as a fraction of her total available hours, so that  $l \in [n\underline{x}, 1]$ , where  $\underline{x}$  is the minimum working hours per patient, and  $n\underline{x}$  is thus the minimum working hours spent on treating all her own patients. We simply assume that  $\underline{x}$  is exogenously given, and it reflects various factors, such as required documentation and other institutional reasons.

The first part,  $V(l, y)$ , referred to as an 'extrinsic payoff,' is a standard payoff that comes from choice of working hours and consumption. We assume that  $V$  is a quasi-linear form of  $V(l, y) = y - c(l)$ , where  $c$  is strictly increasing and strictly convex with  $\lim_{l \rightarrow 1} c(l) = \infty$ , so that there is no income effect, and each physician prefers less working hours in terms of an extrinsic payoff and chooses her working hours within the range of  $[n\underline{x}, 1)$ . For simplicity, we assume that physicians get paid by fixed salary  $w > 0$ , and thus physicians' decision does not depend on their salary in the model.<sup>8</sup>

The second part,  $M$ , in the utility function (1), referred to as an 'intrinsic payoff,' represents sub-utility from non-material and non-labor compartments in preference. Frey and Oberholzer-Gee (1997) stated that intrinsic motivation is related to actions an individual

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<sup>8</sup>Since Ellis and McGuire (1986) discussed superiority of a mixed payment system, there has been several papers to explore the role of physicians payment methods. See Pope (1989), Ellis and McGuire (1990), Selden (1990), Ellis and McGuire (1993), Ma (1994), Glazer and McGuire (1994), Ma and McGuire (1997), Ellis (1998), Chalkley and Malcomson (1998), and Wright (2007). Pope (1989) examines the effect of non-price competition on the quality of medical services provided by hospitals by introducing a slack in a hospital. Ellis and McGuire (1990) expand Ellis and McGuire (1986) by considering the demand side in the bargaining setting, and Selden (1990) re-examines Ellis and McGuire (1986) in welfare by introducing a capitation payment method. Ellis and McGuire (1993) provides a comprehensive survey. Ma (1994) discusses the first best situation for the regulator in terms of reimbursement and prospective payment methods by considering hospitals which are concerned about the quality and the cost of medical services. Glazer and McGuire (1994) also examine a mixture of prospective and reimbursement methods when there are two payers and one hospital in a 3-stage game. Ma and McGuire (1997) propose a 5-stage game-theoretic model in which there are a patient, a physician, and an insurer, and discuss the optimal system under asymmetry of information. Chalkley and Malcomson (1998) also discuss the optimal behavior of the purchaser when she does not have complete information on the quality and the cost of the hospital.

simply undertakes because she likes to do so, or because an individual derives some satisfaction from doing her duty. Although there may be various ways to capture physicians' motivation in medical treatments, we focus on physicians' intrinsic motivation that is only related to mutual interactions among physicians within the same hospital. Specifically, each physician enjoys a higher intrinsic payoff when the health levels of her own patients are higher both absolutely and relatively than those of patients treated by other physicians within the same hospital.

To capture this, we assume in the similar manner to the work of Kandel and Lazear (1992) that an intrinsic payoff is described by the following form:

$$M \equiv m(h, \bar{H}),$$

where  $h$  represents the average health level of her own patients, and the intrinsic payoff,  $M$ , is assumed to be the function not only of the average of whole patients of the hospital,  $\bar{H}$ , but also of the average of her own patients. We assume that the intrinsic payoff is increasing and strictly concave in  $h$ , i.e.  $m_h > 0$  and  $m_{hh} < 0$ , so that each physician enjoys a payoff by increasing the average health level of her own patients, but its marginal increment is decreasing. Figure 1 illustrates the relation between the intrinsic payoff of each physician and the average health level of her own patients.

The crucial assumption in this study is that the marginal payoff associated with intrinsic motivation with respect to the average health level of her own patients is increasing in the average health level of whole patients in the hospital,  $m_{h\bar{H}} > 0$ . A rise (decline) in the average health level of whole patients,  $\bar{H}$ , encourages (discourages) physicians to increase the average health level of their own patients. This change in the intrinsic payoff,  $m_{h\bar{H}}$ , is called the 'motivational shift' associated with a change in the average health level of whole patients treated in the hospital. A larger value of  $m_{h\bar{H}}$  implies that an increase in the average health level of whole patients is associated with a higher level of the motivational shift, and thus

it results in greater encouragement for physicians to give more medical treatments. More specifically, a rise (decline) in the marginal benefit caused by a rise (decline) in  $\bar{H}$  is called ‘motivation-in’ (‘motivation-out’). The motivational shift is a key element in determining the work attitude of physicians in the hospital.

In general, individual’s health level depends on various medical services, and each of medical services is produced by physicians’ labor input and other factors of production (see, e.g., Zweifel and Breyer (1997)). However, for simplicity, we assume that the health of patients only depends on physicians’ working hours per patient,  $x = l/n$ , such that the average health level of physician’s own patients,  $h \equiv h(x)$ , is increasing and strictly concave in  $x$  with its upper bound, i.e.  $h' > 0 > h''$  and  $\lim_{x \rightarrow \infty} h(x) = \bar{h} < \infty$ . This implies that the health level,

$$h \equiv H(l, n),$$

is increasing and strictly concave in physician’s working hours,  $l$ , and it is decreasing in the number of patients per physician  $n$ , i.e.  $H_l > 0$ ,  $H_{ll} < 0$  and  $H_n < 0$ . We also assume that the marginal health level of working hours is increasing in  $n$ , i.e.  $H_{ln} > 0$ .<sup>9</sup> Notice that there is a trade-off in terms of  $l$  for physicians between their intrinsic motivation and extrinsic motivation; an increase in  $l$  is desirable for physicians due to their intrinsic motivation, but it is not due to their extrinsic motivation.

We assume that a mass of physicians is used to conceptualize a society of physicians within the same hospital, where the influential power or ability of each physician is too small to affect the average health level of whole patients, i.e.  $\bar{H}$  is completely external to all physicians when they make a decision. Hence, the classic free-riding behavior is not discussed in this study. With this assumption, we simplify our model, in contrast to the conventional studies in which the Nash solution is applied under the assumption that there are a finite number of agents, and thus we do not discuss the situation in which the effect of actions by

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<sup>9</sup>The sufficient condition for  $H_{ln} > 0$  is that the sensitivity of the marginal health level of working hours per patient, defined by  $\varepsilon(x) \equiv -xh''(x)/h'(x) > 0$ , is large enough to ensure that  $\varepsilon(x) > 1$ .

each individual on the average health level of the hospital is not negligible.

### 3 Analysis

We first examine the rational behavior of each physician when she takes the average health level of whole patients of the hospital,  $\bar{H}$ , as well as the number of patients per physician,  $n$ , as given. We then introduce the concept of a fulfilled expectation equilibrium within the hospital or an ‘in-hospital equilibrium,’ where all physicians’ conjectures about the average health level of whole patients in the hospital coincide with the actual average health level. At this stage, the average health level of the hospital is endogenously determined, taking the number of patients (per physician) as exogenously given. The above two stages are related to the supply of medical services. Finally, taking into account demand for medical services, we attempt to endogenize the number of patients (per physician) by introducing the concept of a ‘social equilibrium.’ In a social equilibrium the corresponding average health level of the hospital and the consistent behavior of each physician are also determined. We further present a plausibility of multiple social equilibria.

#### 3.1 Physician’s Optimal Behavior

We characterize the optimal behavior of each physician who takes the ex-ante (or the conjectural) number of her own patients,  $\bar{n}$ , as well as the ex-ante (or the conjectural) average health level of all patients ( $N = a\bar{n}$ ) in the hospital,  $\bar{H}$ , as given. Since  $\bar{n}$  and  $\bar{H}$  are both taken as given, we call this stage an ‘ex-ante’ situation. On the other hand, when  $\bar{n}$  and  $\bar{H}$  are endogenously determined, we call the stage an ‘ex-post’ situation, which will be discussed later when a social equilibrium is introduced into our discussion. Thus, the values of  $\bar{n}$  and  $\bar{H}$  are regarded as conjectures of all physicians at this stage, and such conjectures are assumed to be identical among all physicians.

Given  $\bar{n}$  and  $\bar{H}$ , each physician chooses  $y$  and  $l$  such that utility (1) is maximized. Notice

that consumption,  $y$ , is always given by  $y = w$ , since the payment scheme is based on a fixed salary method. The following first-order condition characterizes an optimum:

$$c'(l) \geq H_l(l, \bar{n})m_h(H(l, \bar{n}), \bar{H}), \quad (2)$$

with equality under the assumption that an interior solution exists. This condition requires that for each physician the marginal cost of working hours in the extrinsic payoff is equal to the marginal benefit in the intrinsic payoff if her working hours are beyond her minimum working obligation,  $\bar{n}\underline{x}$ . In this study, we say that each physician voluntarily works if she optimally chooses  $l$  which satisfies  $l > \bar{n}\underline{x}$ . Notice that any incentive to voluntarily work does not exist if physicians have no moral motivation. Exploiting the assumed properties in utility, we obtain the following preliminary result:

**Lemma 1 (Optimal Choice of Working Hours)** *Given the ex-ante average health level of all patients in the hospital,  $\bar{H}$ , as well as the ex-ante number of patients of each physician,  $\bar{n}$ , the optimal working hours of each physician are described by:*

$$L^*(\bar{H}, \bar{n}) = \begin{cases} \bar{n}\underline{x} & \text{if } \bar{H} < \tilde{H}(\bar{n}) \\ l^*(\bar{H}, \bar{n}) & \text{if } \bar{H} > \tilde{H}(\bar{n}), \end{cases}$$

where  $l^*(\bar{H}, \bar{n})(> \bar{n}\underline{x})$  is such that the condition (2) is satisfied with equality.

This result implies that each physician voluntarily works ( $L^*(\bar{H}, \bar{n}) > \bar{n}\underline{x}$ ) if the ex-ante average health level of the hospital is large enough, and otherwise she does not work voluntarily ( $L^*(\bar{H}, \bar{n}) = \bar{n}\underline{x}$ ). Given  $\bar{n}$ ,  $\tilde{H} \equiv \tilde{H}(\bar{n})$  denotes the critical value of the ex-ante average health level to determine whether or not each physician voluntarily works, where we have  $\bar{n}c'(\bar{n}\underline{x}) = m_h(h(\underline{x}), \tilde{H}(\bar{n}))h'(\underline{x})$ .<sup>10</sup> Figure 2 illustrates how each physician determines the optimal level of her working hours,  $L^*(\bar{H}, \bar{n})$ . The marginal cost of working hours in

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<sup>10</sup>This can be derived directly from  $c'(\bar{n}\underline{x}) = H_l(\bar{n}\underline{x}, \bar{n})m_h(H(\bar{n}\underline{x}, \bar{n}), \tilde{H})$  with  $H(\bar{n}\underline{x}, \bar{n}) = h(\underline{x})$  and  $H_l(\bar{n}\underline{x}, \bar{n}) = h'(\underline{x})/\bar{n}$ .

the left-hand side in the condition (2) is represented by the upward-sloping curve, while the marginal benefit in the right-hand side is represented by the downward-sloping curve.

We now consider the impact of a change in  $\bar{H}$  and  $\bar{n}$  on the optimal level of working hours. Differentiating  $l^* \equiv l^*(\bar{H}, \bar{n})$  with respect to  $\bar{H}$  and  $\bar{n}$  yields:

$$l_{\bar{H}}^* = \frac{H_l(l^*, \bar{n})m_{h\bar{H}}(H^*, \bar{H})}{\Delta}; \quad l_n^* = \frac{H_{ln}(l^*, \bar{n})m_h(H^*, \bar{H}) + H_l(l^*, \bar{n})H_n(l^*, \bar{n})m_{hh}(H^*, \bar{H})}{\Delta},$$

where  $H^* \equiv H(l^*(\bar{H}, \bar{n}), \bar{n})$  and  $\Delta \equiv c''(l^*) - H_{ll}(l^*, \bar{n})m_h(H^*, \bar{H}) - H_l^2(l^*, \bar{n})m_{hh}(H^*, \bar{H})$ . By the assumed properties of  $c'' > 0$ ,  $H_l > 0$ ,  $H_n < 0$ ,  $H_{ll} < 0$ ,  $H_{ln} > 0$ ,  $m_{hh} < 0$ , and  $m_{h\bar{H}} > 0$ , we obtain the following preliminary results:

**Lemma 2 (Impact of Changes in  $\bar{H}$  and  $\bar{n}$  on the Optimal Working Hours)** *Suppose that the ex-ante average health level of the hospital is relatively large such that  $\bar{H} > \tilde{H}(\bar{n})$ . Then, the optimal working hours,  $L^*(\bar{H}, \bar{n}) = l^*(\bar{H}, \bar{n}) \in (\underline{l}, 1)$ , are increasing in both the ex-ante average health level of the hospital,  $\bar{H}$ , and the ex-ante number of patients of each physician,  $\bar{n}$ , i.e.  $l_{\bar{H}}^* > 0$  and  $l_n^* > 0$ .*

This result can be interpreted as follows. We first consider the relation between the optimal working hours,  $L^*(\bar{H}, \bar{n})$ , and the ex-ante average health level of the hospital,  $\bar{H}$ , taking the ex-ante number of patients of each physician,  $\bar{n}$ , as given at a fixed level. When  $\bar{H}$  is large enough such that  $\bar{H} > \tilde{H}(\bar{n})$ , the positive relationship between  $l^*$  and  $\bar{H}$  depends on the positive sign of  $m_{h\bar{H}}$  or the motivational shift in the intrinsic payoff. A rise in  $\bar{H}$  induces motivation-in in the intrinsic payoff, which stimulates an incentive to improve the health of patients and hence to result in more voluntary work by physicians. The degree of the impact depends on that of the motivational shift induced by a change in  $\bar{H}$ . Graphically, a rise in  $\bar{H}$  causes the dotted line to shift upward and hence the optimal working hours,  $l^*$ , to increase as shown in Figure 2. The kinked thick line in Figure 3 illustrates the relation between  $L^*(\bar{H}, \bar{n})$  and  $\bar{H}$ . Notice that a rise in  $\bar{n}$  causes  $L^*(\bar{H}, \bar{n})$  to shift upward and the

critical value of  $\tilde{H}(\bar{n})$  to shift right, as shown in Figure 3.<sup>11</sup>

We then examine the relation between  $L^*(\bar{H}, \bar{n})$  and  $\bar{n}$ , taking  $\bar{H}$  as given at a fixed level. A change in  $\bar{n}$  affects the optimal choice through two channels. The first channel is associated with the effect on the marginal health level,  $H_l(l, \bar{n})$ ; and the second channel is related to the effect on the marginal intrinsic payoff through a change in the health level,  $m_h(H(l, \bar{n}), \bar{H})$ . The first and the second channels respectively correspond to the first and the second terms in  $l_{\bar{n}}^*$ . On the first channel, a rise in  $\bar{n}$  increases the marginal health level,  $H_l(l, \bar{n})$ , since  $H_{ln} > 0$ . On the second channel, a rise in  $\bar{n}$  decreases the health of patients,  $H(l, \bar{n})$ , which in turn increases the marginal intrinsic payoff,  $m_h(H(l, \bar{n}), \bar{H})$ . Thus, a change in  $\bar{n}$  affects the optimal working hours through an increase in the positive effects through the two channels.

Graphically, a rise in  $\bar{n}$  causes the dotted line to shift upward and hence the optimal working hours,  $l^*$ , to increase as shown in Figure 2. Figure 4 presents the relation between  $\bar{n}$  and  $L^*(\bar{H}, \bar{n})$ . Let  $\tilde{n}(\bar{H})$  be such that  $\tilde{H}(\tilde{n}(\bar{H})) = \bar{H}$ . Then, by Lemma 1,  $L^*(\bar{H}, \bar{n}) = l^*(\bar{H}, \bar{n})$  if  $\bar{n} < \tilde{n}(\bar{H})$ , and  $L^*(\bar{H}, \bar{n}) = \bar{n}\underline{x}$  if  $\bar{n} > \tilde{n}(\bar{H})$ . If there are many patients such that  $\bar{n} > \tilde{n}(\bar{H})$ , each physician never voluntarily works. In contrast, if physicians have a relatively small number of patients such that  $\bar{n} < \tilde{n}(\bar{H})$ , they voluntarily work. The voluntary working hours are represented by the difference between BC and OC in Figure 4. Moreover, notice that a rise in  $\bar{H}$  causes  $L^*(\bar{H}, \bar{n})$  to shift upward and the critical value of  $\tilde{n}(\bar{H})$  to shift right, as shown in Figure 4. This is because the optimal working hours are increasing in  $\bar{H}$ , and the critical value,  $\tilde{n}(\bar{H})$ , is increasing in  $\bar{H}$ .

The average health level of physician's own patients is determined through physician's optimal decision in terms of working hours,  $L^*(\bar{H}, \bar{n})$ . By Lemma 1, given  $\bar{H}$  and  $\bar{n}$ , the

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<sup>11</sup>This is because the optimal working hours are increasing in  $\bar{n}$ , and the critical value,  $\tilde{H}(\bar{n})$ , is increasing in  $\bar{n}$ , since  $\tilde{H}$  satisfies  $\bar{n}c'(\bar{n}\underline{x}) = m_h(h(\underline{x}), \tilde{H}(\bar{n}))h'(\underline{x})$ , so that  $\tilde{H}'(\bar{n}) = \frac{c'(n\underline{x}) + n\underline{x}c''(\bar{n}\underline{x})}{h'(\underline{x})m_{h\bar{H}}(h(\underline{x}), \tilde{H}(\bar{n}))} > 0$ .

resulting (ex-post) average health level of physician's own patients is represented by:

$$H^*(\bar{H}, \bar{n}) \equiv H(L^*(\bar{H}, \bar{n}), \bar{n}) = \begin{cases} h(\underline{x}) & \text{if } \bar{H} < \tilde{H}(\bar{n}) \\ H(l^*(\bar{H}, \bar{n}), \bar{n}) & \text{if } \bar{H} > \tilde{H}(\bar{n}). \end{cases}$$

Differentiating  $H^*(\bar{H}, \bar{n})$  with respect to  $\bar{H}$  under the condition of  $\bar{H} > \tilde{H}(\bar{n})$  yields:

$$H_{\bar{H}}^*(\bar{H}, \bar{n}) = H_l(l^*(\bar{H}, \bar{n}), \bar{n})l_{\bar{H}}^*(\bar{H}, \bar{n}),$$

which measures the impact of a change in the ex-ante average health level of whole patients of the hospital,  $\bar{H}$ , on the ex-post average health level of physician's own patients,  $H^*$ . Since  $H_l > 0$  and  $l_{\bar{H}}^* > 0$ ,  $H^*$  is increasing in  $\bar{H}$ , i.e.  $H_{\bar{H}}^* > 0$ . Moreover,  $H_{\bar{H}\bar{H}}^* = h''(l^*/\bar{n})(l_{\bar{H}}^*/\bar{n})^2 + h'(l^*/\bar{n})(l_{\bar{H}\bar{H}}^*/\bar{n})$  implies that  $H^*$  is strictly concave in  $\bar{H}$  if the concavity of  $h$  is large enough or if the degree of motivational shift is large enough (so that  $l_{\bar{H}}^*$  is large enough).<sup>12</sup>

Similarly, differentiating  $H^*(\bar{H}, \bar{n})$  with respect to  $\bar{n}$  under the condition of  $\bar{H} > \tilde{H}(\bar{n})$  yields:

$$H_{\bar{n}}^*(\bar{H}, \bar{n}) = H_l(l^*(\bar{H}, \bar{n}), \bar{n})l_{\bar{n}}^*(\bar{H}, \bar{n}) + H_{\bar{n}}(l^*(\bar{H}, \bar{n}), \bar{n}) = \frac{h'(l^*/\bar{n})}{\bar{n}} \left( l_{\bar{n}}^* - \frac{l^*}{\bar{n}} \right),$$

which implies that if  $l_{\bar{n}}^* < \frac{l^*}{\bar{n}}$ ,  $H^*$  is decreasing in  $\bar{n}$ , i.e.  $H_{\bar{n}}^* < 0$ . The condition of  $l_{\bar{n}}^* < l^*/\bar{n}$  requires that the optimal choice of working hours is relatively insensitive to a change in the ex-ante number of patients of each physician.

The above arguments are summarized in the following lemma related to the ex-post average health level of physician's own patients,  $H^*(\bar{H}, \bar{n}) \equiv H(L^*(\bar{H}, \bar{n}), \bar{n})$ :

**Lemma 3 (Impact of Changes in  $\bar{H}$  and  $\bar{n}$  on the Ex-Post Patient's Health Level)**

*The ex-post average health level of physician's own patients,  $H^*(\bar{H}, \bar{n})$ , is constant at  $h(\underline{x})$*

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<sup>12</sup>The condition that the concavity of  $h$  is large enough can be interpreted as the assumption that the sensitivity of the marginal health level of working hours per patient, defined by  $\varepsilon(x) \equiv -xh''(x)/h'(x) > 0$ , is large enough such that  $\varepsilon(x) > 1$ .



for  $\bar{H} < \tilde{H}(\bar{n})$  and is increasing in  $\bar{H}$  for  $\bar{H} > \tilde{H}(\bar{n})$ . Moreover, if the concavity of  $h$  is large enough and if  $l_{\bar{n}}^* < l^*/\bar{n}$ , then  $H^*(\bar{H}, \bar{n})$  is strictly concave in  $\bar{H}$  and is decreasing in  $\bar{n}$  for  $\bar{H} > \tilde{H}(\bar{n})$ .

In the rest of the paper, we assume that the concavity of  $h$  is large enough, and  $l_{\bar{n}}^* < l^*/\bar{n}$ , so that Lemma 3 always holds. Figure 5 illustrates this situation where  $H^*$  is increasing and concave in  $\bar{H} > \tilde{H}(\bar{n})$ , and a rise in  $\bar{n}$  causes the graph to shift downward.

### 3.2 In-Hospital Equilibrium

We have examined the optimal behavior of physicians who took both the ex-ante average health level,  $\bar{H}$ , and the ex-ante number of patients of each physician,  $\bar{n}$ , as given. In this subsection, although we still take  $\bar{n}$  as given, we explore an equilibrium outcome within the hospital where the average health level of whole patients is endogenously determined in the model. The number of patients of each physician,  $\bar{n}$ , will be endogenized in the next subsection.

We now introduce the concept of an equilibrium (fulfilled expectations equilibrium), where all physicians correctly conjecture the average health level of whole patients of the hospital. We call it an ‘in-hospital equilibrium.’ In an in-hospital equilibrium, conjectures about the (ex-ante) average health level of whole patients of the hospital which all physicians make prior to their decision making must coincide with the resulting (ex-post) actual average health level of whole patients derived from physicians’ decision problem based on the ex-ante average health level:

$$\hat{H}(\bar{n}) = H^*(\hat{H}(\bar{n}), \bar{n}), \quad (3)$$

where  $\hat{H} \equiv \hat{H}(\bar{n})$  denotes the (average) patient’s health level in an in-hospital equilibrium with  $\bar{n}$  as given. The inspection of this equilibrium condition results in the following lemma:

**Lemma 4 (Existence of In-Hospital Equilibrium)** *Given the ex-ante number of patients of each physician,  $\bar{n}$ , there exists a (stable) in-hospital equilibrium health level  $\hat{H} \equiv \hat{H}(\bar{n}) \geq h(\underline{x})$ .*

As shown in Figure 5 and Lemma 3,  $H^*(\bar{H}, \bar{n})$  is constant at  $h(\underline{x})$  for  $\bar{H} < \hat{H}(\bar{n})$  and is increasing in  $\bar{H}$  for  $\bar{H} > \hat{H}(\bar{n})$  with its upper bound. It is easily observed that the graph of  $H^*(\bar{H}, \bar{n})$  and the 45 degree line have at least one intersection at which the graph of  $H^*(\bar{H}, \bar{n})$  has a smaller slope than unity. Notice that there may be an intersection at which the graph of  $H^*(\bar{H}, \bar{n})$  has a larger slope than unity. However, we only consider the case where the graph of  $H^*(\bar{H}, \bar{n})$  has a smaller slope than unity, since this outcome is only stable.

To check the stability, we consider the in-hospital equilibrium health level,  $\hat{H}(\bar{n})$ , and its neighborhood, where  $H^*(\bar{H}, \bar{n}) > \bar{H}$  for  $\bar{H} < \hat{H}(\bar{n})$  and  $H^*(\bar{H}, \bar{n}) < \bar{H}$  for  $\bar{H} > \hat{H}(\bar{n})$ . We first suppose that conjectures about the average health level of whole patients,  $H^c$ , are a little bit larger than the in-hospital equilibrium level,  $\hat{H}(\bar{n})$ . In this case, the conjectures about the average health level of all patients are larger than the actual ex-post health level of whole patients that was generated based on these conjectures, i.e.  $H^c > H^*(H^c, \bar{n})$ . This in turn causes physicians to revise their conjectures downward. On the other hand, we suppose that conjectures about the average health level of whole patients,  $H^c$ , are a little bit smaller than the in-hospital equilibrium level,  $\hat{H}(\bar{n})$ . In this case, the conjectures about the average health level are smaller than the actual ex-post health level that was generated based on these conjectures, i.e.  $H^c < H^*(H^c, \bar{n})$ . This in turn causes physicians to revise their conjectures upward. As a result, the in-hospital equilibrium is stable.

Lemma 4 shows the existence of an in-hospital equilibrium is guaranteed, but generally the uniqueness is not guaranteed in the model. We now examine the following two cases by considering whether or not multiple stable in-hospital equilibria exist. One case corresponds to the condition where a unique in-hospital equilibrium exists for any  $\bar{n}$  (Case I); and the other case corresponds to the condition where two in-hospital equilibria exist for some  $\bar{n}$  (Case II).

In Case I, for the uniqueness of an in-hospital equilibrium to be guaranteed, it is enough to impose the condition that the graph of  $H^*(\bar{H}, \bar{n})$  and the 45 degree line intersects only once as shown in Figure 5. Lemma 3 says that given  $\bar{n}$ ,  $H^*(\bar{H}, \bar{n})$  is increasing and concave in  $\bar{H}$  with its upper bound for  $\bar{H} > \tilde{H}(\bar{n})$ . If the degree of the motivational shift associated with a change in the ex-ante average health level is relatively small, then the sensitivity of the optimal choice on working hours in response to a change in the ex-ante average health level is relatively small, so that  $l_{\bar{H}}^*(\tilde{H}(\bar{n}), \bar{n})$  is small enough and hence  $H_{\bar{H}}^*(\bar{H}, \bar{n}) = H_l(l^*(\bar{H}, \bar{n}), \bar{n})l_{\bar{H}}^*(\bar{H}, \bar{n}) < 1$  at  $\bar{H} = \tilde{H}(\bar{n})$ . In this situation, the slope of  $H^*(\bar{H}, \bar{n})$  is less than unity for any  $\bar{H}$ , i.e.  $H_{\bar{H}}^*(\bar{H}, \bar{n}) < 1$ . Then, we obtain the following result in Case I:

**Lemma 5 (In-Hospital Equilibrium: Case I)** *Suppose that the degree of the motivational shift is relatively small so that  $H_{\bar{H}}^*(\tilde{H}(\bar{n}), \bar{n}) < 1$  for any  $\bar{n}$ . Then, an in-hospital equilibrium is uniquely determined. Moreover, there exists a unique value of  $\hat{n}$  such that:*

- (1) *Suppose  $\bar{n} < \hat{n}$ . Then, physicians voluntarily work and the corresponding average health level of whole patients of the hospital is above the minimum level, i.e.  $\hat{L}(\bar{n}) > \bar{n}\underline{x}$  and  $\hat{H}(\bar{n}) > h(\underline{x})$ . Moreover,  $\hat{H}(\bar{n})$  is decreasing in  $\bar{n}$ ;*
- (2) *Suppose  $\bar{n} > \hat{n}$ . Then, physicians never voluntarily work and the corresponding average health level of whole patients of the hospital is at the minimum level, i.e.  $\hat{L}(\bar{n}) = \bar{n}\underline{x}$  and  $\hat{H}(\bar{n}) = h(\underline{x})$ .*

This lemma is quite intuitive since physicians having a relatively large number of patients do not work voluntarily for the patients whose health level is at minimum, while physicians having a relatively small number of patients works voluntarily for the patients whose health level is relatively high. In particular, as long as  $\bar{n} < \hat{n}$ , an increase in the number of patients results in patients' health level to decline.

Figures 6 and 7 illustrate this situation. In the figures the dotted line depicts the right-hand side of the in-hospital equilibrium condition (3), and the thick line depicts the left-hand side of the in-hospital equilibrium condition (3). The equilibrium health level,  $\hat{H}$ , is uniquely determined at the intersection. Figure 6 corresponds to the case where physicians do not

work voluntarily with  $\hat{H}(\bar{n}) = h(\underline{x})$ , while Figure 7 corresponds to the case where physicians voluntarily work with  $\hat{H}(\bar{n}) > h(\underline{x})$ . Since a rise in  $\bar{n}$  results in a monotonic decrease in  $H^*(\bar{H}, \bar{n})$  and the graph of  $H^*(\bar{H}, \bar{n})$  to shift downward as shown in Figure 5, the in-hospital equilibrium health level monotonically decreases with a rise in  $\bar{n}$  as long as it is above  $h(\underline{x})$ . Notice that the critical value of  $\hat{n}$  must satisfy that  $\tilde{H}(\hat{n}) = h(\underline{x})$ , in order to determine whether or not the average health level of whole patients of the hospital is larger than the minimum level .

We now turn to Case II where two stable in-hospital equilibria exist. In contrast to Case I, if the degree of the motivational shift associated with a change in the ex-ante average health level is relatively large, then the sensitivity of the optimal choice of working hours in response to a change in the ex-ante average health level is relatively large, so that  $l_{\bar{H}}^*(\tilde{H}(\bar{n}), \bar{n})$  is large enough and hence  $H_{\bar{H}}^*(\bar{H}, \bar{n}) = H_l(l^*(\bar{H}, \bar{n}), \bar{n})l_{\bar{H}}^*(\bar{H}, \bar{n}) > 1$  at  $\bar{H} = \tilde{H}(\bar{n})$ . Thus, the slope of  $H^*(\bar{H}, \bar{n})$  is larger than unity for some  $\bar{H}$ , i.e.  $H_{\bar{H}}^*(\bar{H}, \bar{n}) > 1$ , as shown in Figure 8. In this situation, it is possible to have three intersections of the graph of  $H^*(\bar{H}, \bar{n})$  with the 45 degree line. If there are three intersections, then we have two stable in-hospital equilibria that are represented by points A and B (point C is a unstable in-hospital equilibrium).

Noticing that  $H^*(\bar{H}, \bar{n})$  is constant at  $h(\underline{x})$  for any  $\bar{H} < \tilde{H}(\bar{n})$  and is decreasing in  $\bar{n}$  for any  $\bar{H} > \tilde{H}(\bar{n})$ , and also that  $\tilde{H}(\bar{n})$  is increasing in  $\bar{n}$ , we obtain the following result for Case II:

**Lemma 6 (In-Hospital Equilibrium: Case II)** *Suppose that the degree of the motivational shift is relatively large so that  $H_{\bar{H}}^*(\tilde{H}(\bar{n}), \bar{n}) > 1$  for any  $\bar{n}$ . Then, there exist two values of  $\hat{n}_1$ , and  $\hat{n}_2$  with  $\hat{n}_1 < \hat{n}_2$  such that:*

- (1) *Suppose  $\bar{n} < \hat{n}_1$ . Then, there is a unique in-hospital equilibrium, where physicians voluntarily work and the corresponding average health level of whole patients of the hospital is above the minimum level, i.e.  $\hat{L}(\bar{n}) > \bar{n}\underline{x}$  and  $\hat{H}(\bar{n}) > h(\underline{x})$ . Moreover,  $\hat{H}(\bar{n})$  is decreasing in  $\bar{n}$ ;*
- (2) *Suppose  $\bar{n} > \hat{n}_2$ . Then, there is a unique in-hospital equilibrium, where physicians never*

work voluntarily and the corresponding average health level of whole patients of the hospital is at the minimum level, i.e.  $\hat{L}(\bar{n}) = \bar{n}\underline{x}$  and  $\hat{H}(\bar{n}) = h(\underline{x})$ .

(3) Suppose  $\bar{n} \in (\hat{n}_1, \hat{n}_2)$ . Then, there exist two in-hospital equilibria. In one equilibrium, physicians voluntarily work and the corresponding average health level of whole patients of the hospital is above the minimum level, i.e.  $\hat{L}(\bar{n}) > \bar{n}\underline{x}$  and  $\hat{H}(\bar{n}) > h(\underline{x})$ , and  $\hat{H}(\bar{n})$  is decreasing in  $\bar{n}$ . In the other equilibrium, physicians never work voluntarily and the corresponding average health level of whole patients of the hospital is at the minimum level, i.e.  $\hat{L}(\bar{n}) = \bar{n}\underline{x}$  and  $\hat{H}(\bar{n}) = h(\underline{x})$ .

Since a rise in  $\bar{n}$  induces the graph of  $H^*(\bar{H}, \bar{n})$  to shift right as shown in Figure 9, it is observed that there is one intersection for a relatively small  $\bar{n}$  or for a relatively large  $\bar{n}$ , and also that there are three intersections for the intermediate range of  $\bar{n}$ . The kinked curves ABC and AB'C' correspond to the values of  $\hat{n}_1$  and  $\hat{n}_2$  respectively to determine whether one or three intersections exist, i.e. one or two in-hospital equilibria exist. The intermediate case, where two in-hospital equilibria exist, corresponds to a value of  $\bar{n}$  within the region of  $(\hat{n}_1, \hat{n}_2)$ . Notice that since the motivational shift is attributed to the concavity of  $H^*(\bar{H}, \bar{n})$  the intermediate case of multiple in-hospital equilibria is more likely to emerge when physicians have a larger degree of the motivational shift.

We next examine the impact of a change in the ex-ante number of patients on working hours in in-hospital equilibrium, focusing on a situation where the optimal working hours in in-hospital equilibrium are larger than the minimum level,  $\hat{L}(\bar{n}) > \bar{n}\underline{x}$ . This corresponds to the unique in-hospital equilibrium for  $\bar{n} < \hat{n}$  in Case I and for  $\bar{n} < \hat{n}_1$  in Case II. This also corresponds to one of the two in-hospital equilibria for  $\bar{n} \in (\hat{n}_1, \hat{n}_2)$  in Case II. Differentiating  $\hat{L}(\bar{n}) = l^*(\hat{H}(\bar{n}), \bar{n})$  with respect to  $\bar{n}$  yields:

$$\hat{L}'(\bar{n}) = l_{\bar{n}}^*(\hat{H}(\bar{n}), \bar{n}) + l_{\bar{H}}^*(\hat{H}(\bar{n}), \bar{n})\hat{H}'(\bar{n}). \quad (4)$$

In general, the impact of a change in  $\bar{n}$  on  $\hat{L}(\bar{n})$  is ambiguous. As shown in Lemma 2, a rise

in  $\bar{n}$  increases the optimal choice of working hours (the first-term in equation (4)), and at the same time a decline in the health level associated with the rise in  $\bar{n}$  induces the motivational shift (motivational-out) and hence discourages physicians to voluntarily work (the second-term in equation (4)). Thus, since the latter effect associated with the motivational-out offsets the former effect, whether or not a change in  $\bar{n}$  positively affects the optimal working hours in in-hospital equilibrium highly depends on the degree of the motivational shift. If the motivational shift is relatively significant, the motivational-out associated with the decline in the health level is dominant, so that the optimal working hours in equilibrium decrease. In contrast, if the motivational shift is relatively insignificant, the positive impact of a rise in  $\bar{n}$  on the optimal choice of working hours is dominant, and the optimal working hours in in-hospital equilibrium thus increase.

### 3.3 Social Equilibrium

In the previous subsection we have examined the equilibrium outcome of the supply side of medical services, where the number of patients has been assumed to be given exogenously. The relationship between the in-hospital equilibrium (average) health level of whole patients of the hospital and the ex-ante number of patients per physician has been described by the condition (3) or  $H = \hat{H}(\bar{n})$ . In particular, we have focused on the two cases; Case I where a unique in-hospital equilibrium exists for any  $\bar{n}$ , and Case II where two in-hospital equilibria exist for some range of  $\bar{n}$ . It has also been shown that these cases are closely related to the degree of the motivational shift.

We now incorporate demand for medical services into the model in order to discuss a ‘social equilibrium,’ where the demand level coincides with the supply level. The number of patients is now endogenized in the model. As in the previous subsection, we focus on the two cases, Case I and Case II. For each of the cases, we attempt to discuss the impact of a change in the number of physicians within the hospital on the social equilibrium.

Recall that the number of patients,  $N = an$ , simply depends on the average health level

of whole patients of the hospital, i.e.  $an = D(H)$ , or

$$H = D^{-1}(an),$$

where  $D^{-1}$  is the inverse function of  $D$ , and it is increasing and strictly convex. In a social equilibrium, the average health level of whole patients,  $\check{H} \equiv \check{H}(a)$ , and the number of patients per physician,  $\check{n} \equiv \check{n}(a)$ , are both determined by the demand-side condition of  $\check{H} = D^{-1}(a\check{n})$  and the (supply-side) in-hospital equilibrium condition of  $\check{H} = \hat{H}(\check{n})$ .

We now explore Case I where there exists a unique in-hospital equilibrium for any number of each physician's patients,  $n$ , as described in Lemma 5. This case corresponds to the one where the degree of the motivational shift is relatively small. In Figure 10, the down-sloping kinked curve represents the supply-side behavior in in-hospital equilibrium (as shown in Lemma 5), while the up-sloping dotted curve represents the demand-side behavior. The number of patients per physician and the (average) health level of whole patients in a social equilibrium,  $(\check{n}(a), \check{H}(a))$ , are determined at the intersection of these two curves, namely point A. Notice that a rise in  $a$  results in the dotted curve being shifted left. Then, we summarize the result in the following proposition:

**Proposition 1 (Social Equilibrium: Case I)** *Suppose that the degree of the motivational shift is relatively small so that  $H_H^*(\check{H}(n), n) < 1$  for any  $n$ . Then, there exists a unique social equilibrium. Moreover, there exists a unique value  $\check{a}$  such that in a social equilibrium:*

- (1) *the average health level of the hospital is constant at the minimum level,  $\check{H}(a) = h(\underline{x})$ , for any  $a < \check{a}$ ; and*
- (2) *the average health level of the hospital is larger than the minimum level,  $\check{H}(a) > h(\underline{x})$ , for any  $a > \check{a}$ .*

*Furthermore, for any  $a > \check{a}$ , the average health level of the hospital is increasing in the number of physicians,  $a$ , i.e.  $\check{H}'(a) > 0$ .*

The result of this proposition is quite intuitive, as in Lemma 5. When physicians have

many patients so that  $a < \check{a}$ , they have no incentive to voluntarily work and only provide the minimum level of medical services to their patients. In contrast, when physicians face the relatively small number of patients so that  $a > \check{a}$ , they have an incentive to voluntarily work, thus resulting in a higher health level of patients. In this case, a rise in the number of physicians increases the health level, since it induces the up-sloping dotted curve to shift upward without any influence on the down-sloping curve in Figure 10. Since the intersection of the two curves must be the kinked point when  $n = \hat{n}$ , the critical value,  $\check{a}$ , must satisfy that  $h(\underline{x}) = D^{-1}(\hat{n}\check{a})$ .

We then study Case II where there exist two in-hospital equilibria for some region of  $n$ , as described in Lemma 6. This case corresponds to the one where the degree of the motivational shift is relatively large. In Figure 11, both the down-sloping thick curve and the horizontal thick line represent the supply level of medical services (as described in Lemma 6), while the up-sloping dotted curve represents the demand level of medical services. Notice that two in-hospital equilibria exist for  $n \in (\hat{n}_1, \hat{n}_2)$ . The social equilibrium,  $(\check{n}(a), \check{H}(a))$ , is determined at the intersection of these two graphs.

We can have three different types of social equilibrium outcomes. First of all, if the number of physicians is relatively large, there exists a unique social equilibrium where a higher health level is attained through physicians' voluntary work. This social equilibrium corresponds to point C in Figure 11. Secondly, if the number of physicians is relatively small, there also exists a unique social equilibrium where the minimum health level is attained without any physicians' voluntary work. This social equilibrium corresponds to point D. Finally, most importantly, if the number of physicians is in the intermediate range, there exist two social equilibria, where a higher health level is attained through physicians' voluntary work in one equilibrium (point B), and the minimum health level is attained without any voluntary work in the other (point A).<sup>13</sup> We then summarize the result in the following

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<sup>13</sup>Technically, we have another possibility that the graph of  $H = D^{-1}(an)$  passes through between the two separated thick graphs of  $H = \hat{H}(n)$  without any intersection, so that there exists no social equilibrium. For our explanatory purpose, we exclude this possibility so that there is a social equilibrium for all possible  $a$ .



proposition:

**Proposition 2 (Social Equilibrium: Case II)** *Suppose that the degree of the motivational shift is relatively large so that  $H_{\bar{H}}^*(\tilde{H}(n), n) > 1$  for any  $n$ . Then, there exist two values,  $\check{a}_1$  and  $\check{a}_2$ , with  $\check{a}_1 < \check{a}_2$ , such that:*

- (1) *for any  $a < \check{a}_1$ , there exists a unique social equilibrium, where the average health level of hospital is constant at the minimum level,  $\check{H}(a) = h(\underline{x})$ ;*
- (2) *for any  $a > \check{a}_2$ , there exists a unique social equilibrium, where the average health level of the hospital is larger than the minimum level,  $\check{H}(a) > h(\underline{x})$ ; and*
- (3) *for any  $a \in (\check{a}_1, \check{a}_2)$ , there exist two social equilibria, where the average health level of hospital is constant at the minimum level,  $\check{H}(a) = h(\underline{x})$ , in one social equilibrium, and the average health level of hospital is larger than the minimum level,  $\check{H}(a) > h(\underline{x})$ , in the other. Furthermore, the average health level of the hospital is increasing in the number of physicians,  $\check{H}'(a) > 0$ , whenever the average health level of the hospital is larger than the minimum level.*

It would be worth emphasizing that we have a possibility of multiple social equilibria. Notice that a larger degree of the motivational shift is more likely to result in multiple in-hospital equilibria and hence multiple social equilibria to emerge. Each of the social equilibria attains the different behavior of physicians, the different health level, and the different total number of patients in the hospital. Such multiplicity induces the indeterminacy of the resulting outcome.

When there are multiple social equilibria, we always have the situation such that in one social equilibrium there is a hospital with physicians with long working hours, achieving higher health levels in patients. In the other, there is a hospital with physicians with less working hours, not being able to achieve as high health levels. In the former equilibrium the endogenously determined number of patients is larger than that in the latter. Intrinsic motivation of physicians contributes to a possibility of the presence of multiple social equilibria. In the former social equilibrium, every physician works longer hours because others do so, whereas in the latter every physician does not work long hours, because nobody does

so. This shows the positive relation between attractiveness of the hospital for patients and the health level of patients (satisfaction level). Notice also that the multiplicity induces the trade-off relation between the extrinsic payoff for physicians and the health level of patients: the higher health level of patients associated with the lower extrinsic payoff for physicians in one social equilibrium, and the lower health level of patients associated with the larger extrinsic payoff for physicians in the other social equilibrium.

The existence of multiple social equilibria could provide an explanation of a possibility that the health level of patients treated in the hospital and the work attitude of physicians are different among hospitals, although the managerial environment seems almost identical among hospitals. This multiplicity has been driven by the motivational shift in the intrinsic payoff for physicians in our model, and our results are in accordance with the observations that collective actions are sometimes successful but sometimes not, as emphasized by Ostrom (1990).

## 4 Conclusion

The understanding of physicians' motivation would be important to evaluate medical systems since their motivation seems different from other types of workers. One crucial issue of this study has been that physicians' preference also depends on intrinsic motivation that is captured by the mutual relation between the health level of her own patients and those of patients treated by other physicians within the same hospital. Focusing on this mutual interactions among physicians, we have studied the relation between the work attitude of physicians and the health of their patients in a single hospital, and we have presented a possibility of the presence of multiple equilibria.

We have shown that equilibrium outcomes depend on the number of physicians employed, and also discussed the possible existence of two social equilibria. Such multiplicity inducing the indeterminacy of resulting outcomes is attributed to the motivational shift associated

with a change in the average health level of the hospital.

Our results also provide a possible explanation for the observable phenomenon of there being a significant difference in the work attitudes of physicians and medical treatments among different private/public hospitals, even though each their own management environment seems almost identical.

Finally we should mention a drawback of this paper. Although we have presented a model to explain why there are different hospitals with different physicians in the similar environments, we have not incorporated any government policies into our model. Various policy reforms of medical systems would affect physicians' behavior. Since we have not incorporated any policy instruments into our model, we cannot evaluate government health policies, while we agree on an argument that one social equilibrium is superior to the other in welfare. In other words, we cannot investigate government tools to move our society from a worse social equilibrium to a better one. Thus, one of directions to extend our model would be to incorporate some government health policies to change environments of medical care, and also to explore the policies by evaluating different social equilibria in welfare.

## References

- ARROW, K. J. (1963): "Uncertainty and the Welfare Economics of Medical Care," *American Economic Review*, 53, 941–969.
- BARRON, J. M., AND K. P. GJERDE (1997): "Peer Pressure in an agency relationship," *Journal of Labor Economics*, 15, 234–254.
- BATEMAN, T., AND D. W. ORGAN (1983): "Job Satisfaction and the Good Soldier: The Relationship between Affect and Employee "Citizenship"," *Academy of Management Journal*, 26, 587–596.

- BERNHEIM, B. D. (1994): “A Theory of Conformity,” *Journal of Political Economy*, 102, 841–877.
- CHALKLEY, M., AND J. M. MALCOMSON (1998): “Contracting for Health Services when Patient Demand Does not Reflect Quality,” *Journal of Health Economics*, 17, 1–19.
- COLEMAN, J. (1990): *Foundation of Social Theory*. Harvard University Press, Cambridge, MA.
- DUGGAN, M. G. (2000): “Hospital Ownership and Public Medical Spending,” *Quarterly Journal of Economics*, 140, 1343–1373.
- ELLIS, R. P. (1998): “Creaming, Skimping and Dumping: Provider Competition on the Intensive and Extensive Margins,” *Journal of Health Economics*, 17, 537–555.
- ELLIS, R. P., AND T. G. MCGUIRE (1986): “Provider Behaviour under Prospective Reimbursement,” *Journal of Health Economics*, 5, 129–151.
- (1990): “Optimal Payment Systems for Health Services,” *Journal of Health Economics*, 9, 375–396.
- (1993): “Supply-Side and Demand-Side Cost Sharing in Health Care,” *Journal of Economic Perspectives*, 4, 135–151.
- EVANS, R. G. (1974): “Supplier-Induced Demand: Some Empirical Evidence and Implications,” in *The Economics of Health and Medical Care*, ed. by M. Perlman. Macmillan, London.
- FREY, B. S. (1993): “Shirking or Work Morale?,” *European Economic Review*, 37, 1523–1532.
- FREY, B. S., AND F. OBERHOLZER-GEE (1997): “The cost of price incentives: An empirical analysis of motivation crowding-out,” *American Economic Review*, 87(4), 746–755.

- GLAZER, J., AND T. G. MCGUIRE (1994): "Payer Competition and Cost Shifting in Health Care," *Journal of Economics and Management Strategy*, 3(1), 71–92.
- HEYES, A. (2005): "The Economics of Vocation or 'Why is a Badly Paid Nurse a Good Nurse'?", *Journal of Health Economics*, 24, 561–569.
- HOLLANDER, H. (1990): "A Social Exchange Approach to Voluntary Cooperation," *American Economic Review*, 80, 1157–1167.
- KANDEL, E., AND E. P. LAZEAR (1992): "Peer Pressure and Partnerships," *Journal of Political Economy*, 100, 801–817.
- LINDBECK, A. (1997): "Incentives and Social Norms in Household Behavior," *American Economic Review*, 87, 370–377.
- MA, C.-T. A. (1994): "Health Care Payment Systems: Cost and Quality Incentives," *Journal of Economics and Management Strategy*, 3, 93–112.
- MA, C.-T. A., AND T. G. MCGUIRE (1997): "Optimal Health Insurance and Provider Payment," *American Economic Review*, 87(4), 685–704.
- MANSKI, C. F. (2000): "Economic Analysis of Social Interactions," *Journal of Economic Perspectives*, 14, 115–136.
- MCGUIRE, T. G. (2000): "Physician Agency," in *Handbook of Health Economics*, ed. by A. J. Culyer, and J. P. Newhouse. Elsevier, Amsterdam.
- OSTROM, E. (1990): *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press, Cambridge.
- POPE, G. C. (1989): "Hospital Nonprice Competition and Medicare Reimbursement Policy," *Journal of Health Economics*, 8, 147–172.

- REGE, M. (2004): “Social Norms and Private Provision of Public Goods,” *Journal of Public Economic Theory*, 6, 65–77.
- SELDEN, T. M. (1990): “A Model of Capitation,” *Journal of Health Economics*, 9, 397–409.
- SIMOENS, S., AND A. GIUFFRIDIA (2004): “The Impact of Physician Payment Methods on Raising the Efficiency of the Healthcare System,” *Applied Health Economics and Health Policy*, 3, 39–46.
- TAYLOR, L. J. (2007): “Optimal Wages in the Market for Nurses: An Analysis Based on Heyes’ Model,” *Journal of Health Economics*, 26, 1027–1030.
- TURNIPSEED, D. L. (2002): “Are Good Soldiers Good? Exploring the Link between Organization Citizenship Behavior and Personal Ethics,” *Journal of Business Research*, 55, 1–15.
- WRIGHT, D. J. (2007): “Specialist Payment Schemes and Patient Selection in Private and Public Hospitals,” *Journal of Health Economics*, 26, 1014–1026.
- ZWEIFEL, P., AND F. BREYER (1997): *Health Economics*. Oxford University Press, New York.

Figure 1  
Payoff from Intrinsic Motivation

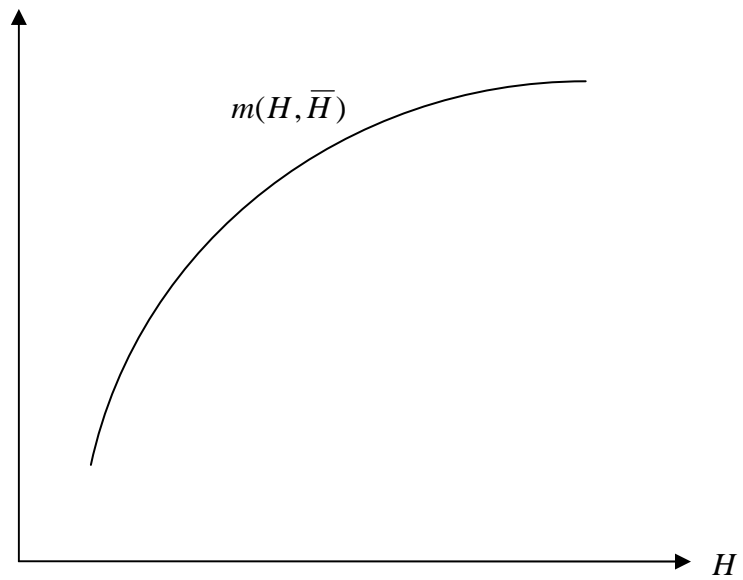


Figure 2  
Physician's Optimal Decision

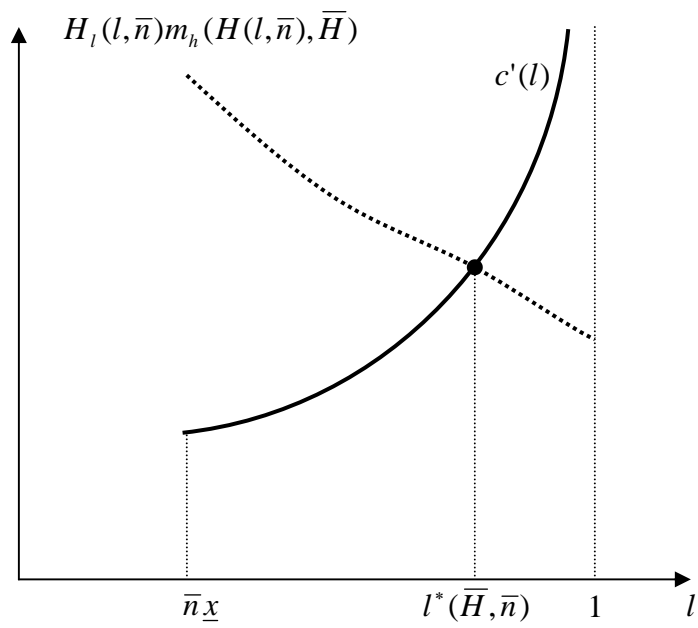


Figure 3  
Optimal Work Time and Ex-Ante Average Health Level

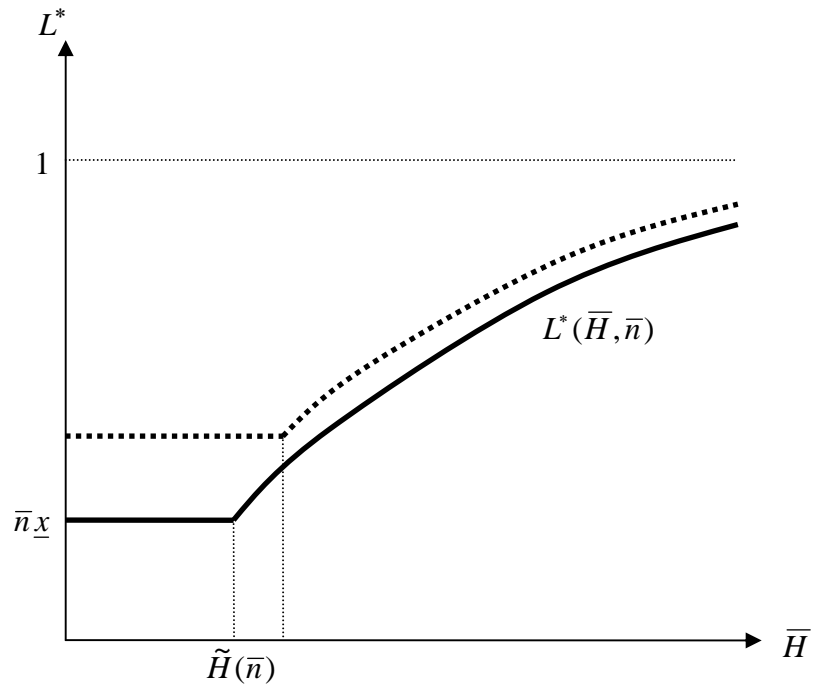


Figure 4  
Optimal Work Time and Ex-Ante Number of Each Physician's Patients

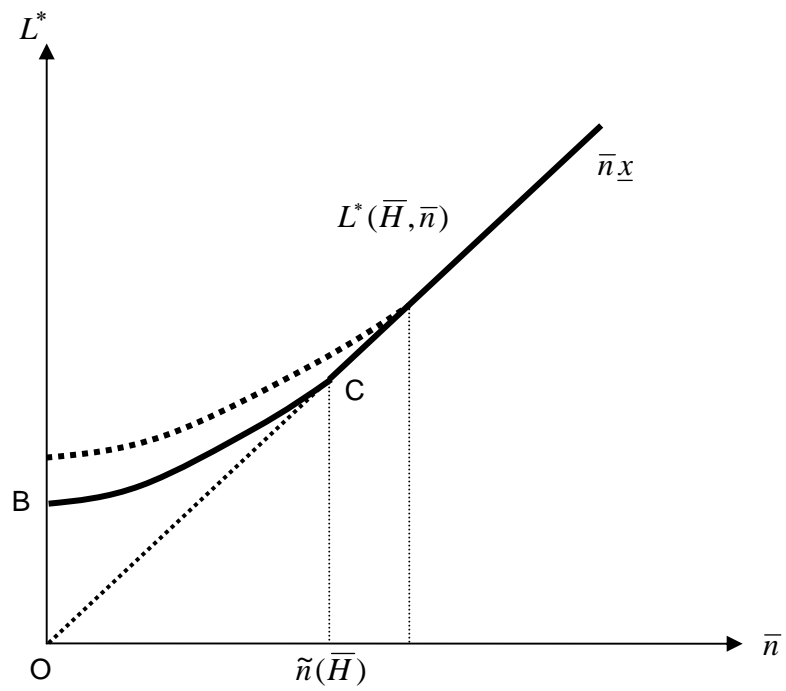




Figure 5  
 Ex-Ante and Ex-Post Health Levels

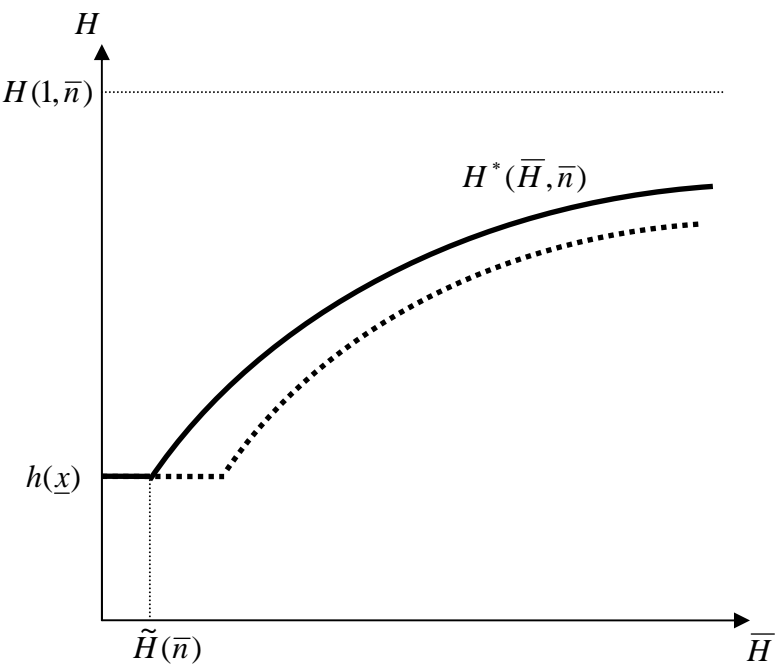


Figure 6  
 Unique Stable In-Hospital Equilibrium  
 No Voluntary Work

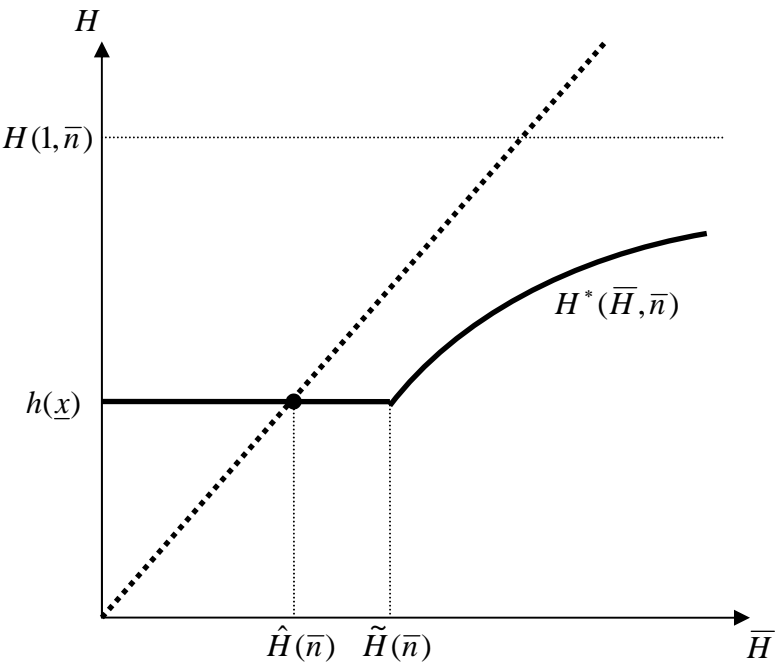


Figure 7  
 Unique Stable In-Hospital Equilibrium  
 Positive Voluntary Work

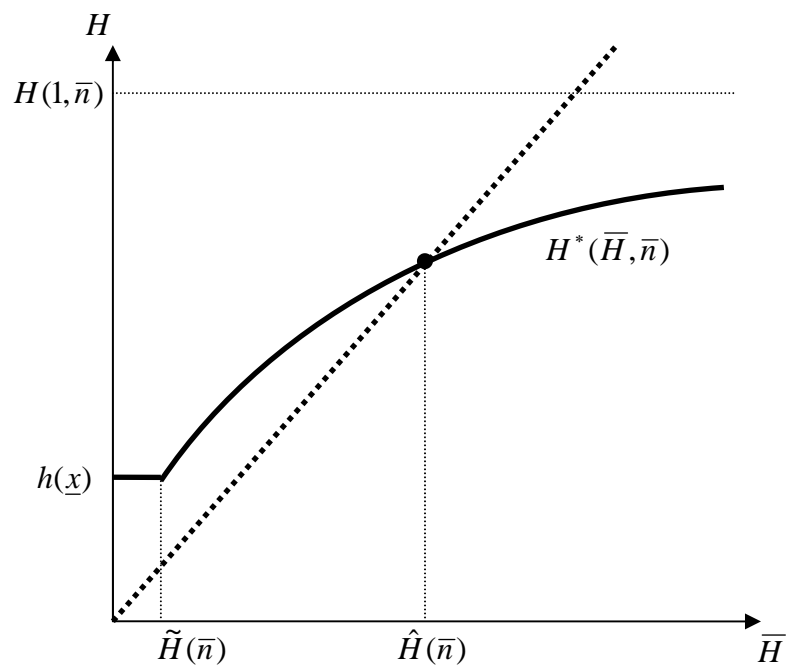


Figure 8  
 Multiple Stable In-Hospital Equilibria

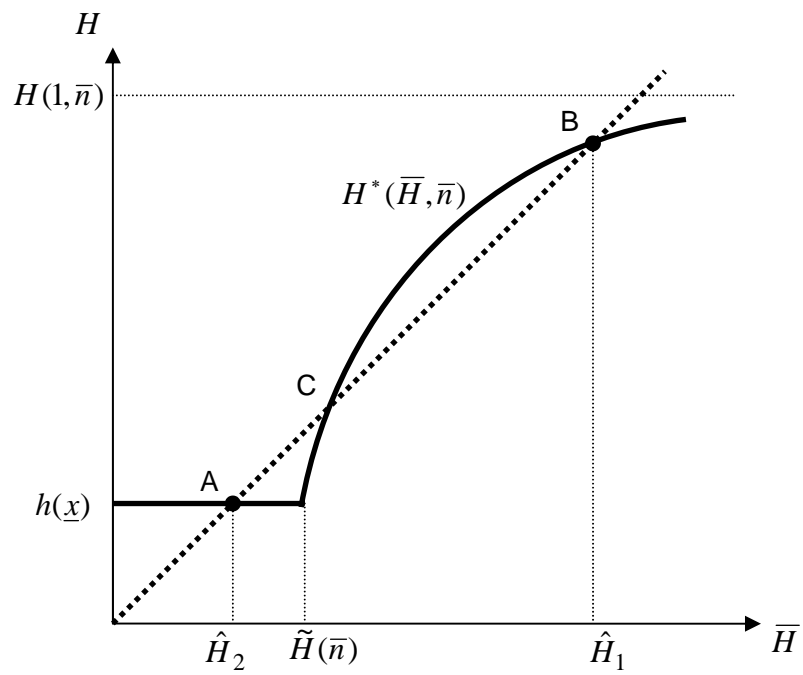


Figure 9  
Multiple Stable In-Hospital Equilibria

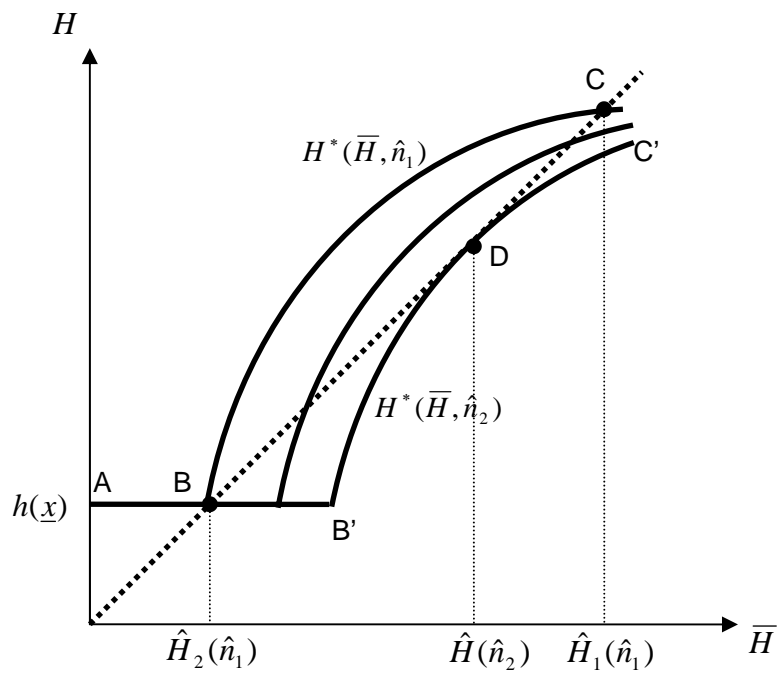


Figure 10  
Unique Social Equilibrium

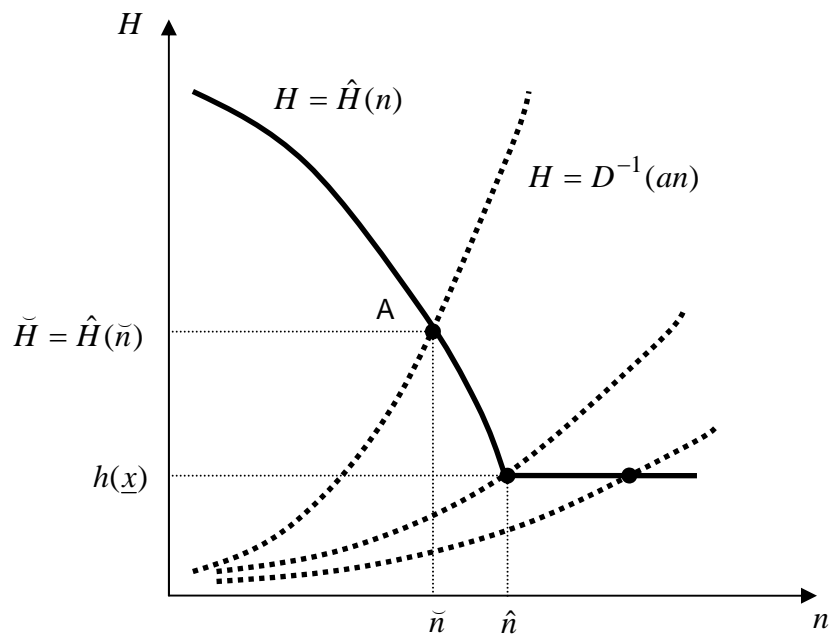


Figure 11  
Multiple Social Equilibria

