Prospective payment system : consequences for hospital-physician interactions in the private sector*

Coudeville Laurent, Mauleon Ana[†], Dervaux Benoît
CRESGE-LABORES (URA 362, CNRS), Université Catholique de Lille, France

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Abstract

In 2004, French health authorities plan to introduce a prospective payment system for hospitals delivering acute care based on the DRG classification system. In this paper, we analyze the consequences of this switch from a retrospective to a prospective payment system on the ability of physicians and hospital managers to coordinate their activity in the production of hospital stays. Our analysis follows those of Dor and Watson (1995) and Custer et al. (1990) but is adapted to the context of the French hospital private sector. Different types of interactions are considered: non-cooperative, dominant-reactive, and cooperative. The main result of this analysis is that, in a context in which average per-patient fees are maintained, the change of payment system is potentially gainful for both partners. Although their fees are not concerned by the reform, physicians are even in a better position than hospitals to take advantage of the change of payment system. A minimum level of coordination is nevertheless required, i.e. either cooperative or dominant-reactive interactions. Furthermore, two elements limits the importance of these potential gains : these are only one-shot gains and hence depend on the ability to reduce the length of hospital stays. Finally, some extensions regarding competition between public and private hospitals and negotiation issues are discussed.

Keywords : prospective payment system, retrospective payment system, physician behaviour, for-profit hospitals

JEL classification : I11, D4, D2

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†Corresponding author address: LABORES, Université Catholique de Lille, 60 Boulevard Vauban, F-59016 Lille Cédex, France. E-mail: amauleon@cresge.fr, Tel: 0033-20134060, Fax: 0033-20134070.

1 Introduction

Following a experimental phase in 2003, a new prospective payment system known as "Tarification à l'Activité" or T2A will be implemented from 2004 in France for all kinds of hospitals providing acute care (public, nonprofit and for-profit). Basically, this new prospective payment system is based on a fixed payment identical for all hospital stays classified in the same Diagnosis Related Group (DRG). If an increased competition is one of the objectives of this reform, tariffs applicable to public and quasi-public hospitals on one side, and for-profit hospitals on the other side, will nevertheless remain initially different.[1] Furthermore, as regards to the private for-profit sector, this new payment system will only affect payments related to charges supported directly by the hospital (nursing care, use of operating rooms, drug consumption, etc.). Fee-for-services paid to physicians working in these hospitals are not affected.

This change in payment schedules is likely to have a strong direct or indirect impact for all categories of economic agents involved (physicians, other health care professionals, hospital managers, patients, health authorities). The consequences of prospective and retrospective payment systems has been a major topic in health economics literature. A lot of works are focused on the advantages and drawbacks of different payment systems from a collective standpoint. In the case demand depends on the quality of care services provided, Ma (1994), Chalkley and Malcomsom (1998) and Mougeot (2000) have shown that the introduction of a prospective payment system will imply productive efficiency (the minimization of per-patient costs) and allocative efficiency (the treatment of the socially optimal number of patients). Other studies [Foster (1985), Ellis and MacGuire (1985)] have generally determined that the incentives inherent to the prospective payment systems will lead to either an undersupply of services or a tendency to selectively admit low-cost cases. Finally, Newhouse (1996) points out the value of a payment system based on a mix between a prospective and a retrospective system.

In this paper, we do not consider social optimum issues, but rather the impact of the payment system on interactions between hospital managers and physicians in the private for-profit sector. In fact, even if physicians' fees are not directly concerned by the reform, adaptation of private hospitals to the new payment system is actually clearly dependent on the way physicians will react to the reform. Indeed, the passive role that Pauly and Redisch (1973) and Harris (1977) assigned to management may have been a plausible assumption at the time. Currently, managers are playing an increasingly proactive role in allocative decisions within the hospital. With the implementation of prospective payment systems and other cost controls, hospital managers and physicians may find that they have conflicting interests. Analyzing hospital-physician interactions is then essential for understanding how private hospitals, as a whole, will react to

[1] Further information on this reform are available on the website of the French Health Ministry (www.sante.gouv.fr/htm/dossiers/hopital2007)

the introduction of the new payment system.[2]

Custer et al. (1990) and Dor and Watson (1995) analyzed how different payment systems affect hospital-physicians interactions. Custer et al. (1990) treated hospital-physician interactions from a productive efficiency angle without directly taking into account the impact on patients' demand. Dor and Watson (1995) compared two kind of prospective payment systems: a single fee to be shared between hospital and physicians and distinct fees for each of them. The analysis presented here is based on these previous works but is more directly related to the context and the questions raised by the implementation of a prospective payment system for private hospitals in France. In order to preserve tractability and ease of exposition, we use a simple model to analyze hospital-physician interactions.

Specifically, we study the choices of a pairing made up of a representative physician and a hospital manager facing patient's demand sensitive to the level of medical care, the length of hospital stay and the level of inputs provided by the hospital. The couple also has to take into account the constraint fixed by health authorities on the number of beds available for the hospital. We model the relationships between the physician and the hospital manager under non-cooperative, dominant-reactive, and cooperative assumptions. These relationships are analyzed by adapting Cournot, Stackelberg, and cartel models from duopoly theory, respectively. The results show the non-symmetric nature of the hospital-physician interaction (in some cases, the hospital can be interested in letting the physician act as leader); the key role played by the constraint on the number of beds (it destroys the uniqueness of the Cournot equilibrium); and the clear incentives to cooperate (the sum of profits is always higher in the case of cooperation). The implementation of a DRG based prospective payment is always gainful for both the hospital and the physician if the level of payment per patient is maintained with respect to the current retrospective payment system. These are nevertheless one-time gains depending on the conditions fixed by health authorities for the new payment system. This analysis also shows the sensitivity of the gains to the importance of the constraint on the number of beds. Finally, the results bring out that, in the non-cooperative case, physicians are more likely to obtain rather than to lose benefits from the change of hospital payment system.

The paper is organized as follows. In Section 2, the model is presented. Section 3 describes hospital-physician interactions under the current retrospective payment system. Section 4 analyzes hospital-physician interactions under the new prospective payment system. Finally, Section 5 concludes and discusses some possible extensions.

[2] In a recent paper, Eggleston et al. (2001) provide a theoretical model to study how for-profit, nonprofit, and public providers respond to a prospective payment system in the presence of cost uncertainty.

2 The model

Following Dor and Watson (1995), our model is based on a "couple" made up of a hospital manager and a representative physician having to coordinate their actions in order to produce homogeneous hospital stays. This couple faces patients' demand that is sensitive to the quality of care provided by the physician or its level of effort e, to the length of stay h and to the level of inputs provided by the hospital q. As presented here, hospital inputs encompass both those directly related to care (nursing care, drugs, operating rooms,...) and those improving patients' comfort (bedding, food, ...). To take into account activity constraints (which is a key element of the regulation of private for-profit hospitals by French health authorities), we constrain the number of available beds in the hospital.

Patients' utility function is assumed to be additive, continuous, and concave in each of its arguments ($E_{ee} < 0, H_{hh} < 0, Q_{qq} < 0$):

$$U(e,h,q) = E(e) + H(h) + Q(q) \tag{1}$$

Utility is furthermore assumed to be a strictly increasing function of the physician's effort e and of the level of inputs provided by the hospital q. Regarding the length of stay h, we assume the existence of a threshold $\overline{h}$ beyond which patients' utility begin to decrease: $\overline{h} = \{h \in \mathbb{R}^+ \mid H_h = 0\}$. In other words, patients do not appreciate stays that are either too long or too short. All patients have the same utility function but each of them choose the hospital only if the associated utility is equal or higher than a given threshold which is patient specific. With a population size normalize to 1 and a threshold level uniformly distributed between $\underline{U}$ and $\overline{U}$, the demand faced by the couple hospital-physician can be expressed as follows:

$$D(e,h,q) = \begin{cases} 0 & if \quad U \leq \underline{U} \\ \frac{U(e,h,q)}{\overline{U}-\underline{U}} & if \quad \overline{U} < U < \underline{U} \\ 1 & if \quad U \geq \overline{U} \end{cases} \tag{2}$$

In the remainder of the paper, we will consider only interior solutions ($0 < D(e,h,q) < 1$).

The physician controls both his effort level and the length of stay. He aims at maximizing his net income, i.e., his fees minus costs involved by his activity. His objective function is given by the following expression:

$$\Pi^M(e,h) = D(e,h,q)\left[RM(e) - CM(e)\right] \tag{3}$$

The per-patient cost $CM(e)$ is assumed to be continuous, increasing and convex in e ($CM_e > 0, CM_{ee} > 0$) with $CM(0) = 0$. Fees depend linearly on the effort level : $RM(e) = r_e e$. This specification allows identifying a level of effort $\widetilde{e}$ for which the physician maximizes his per-patient net income: $\widetilde{e} = \{e \in \mathbb{R}^+ \mid RM_e = CM_e\}$.

The hospital manager maximizes hospital's profit:

$$\Pi^H(q) = D(e,h,q)\left[RH\left(h\right) - CH(h)\right] - c_q q \tag{4}$$

Two kinds of costs are borne by the hospital: those related to the level of inputs that are independent of the number of patients treated, $c_q q$, and those that depend on the per-patient length of stay, $CH(h)$, defined as a continuous, increasing and concave function ($CH_h > 0, CH_{hh} < 0$) with $CH(0) = 0$. The daily cost borne by the hospital is then assumed to be decreasing. Fees received by the hospital differ according to the type of payment system. Under the retrospective payment system, fees are defined as a linear function of the length of stay: $RH(h) = r_h h$. Under the prospective payment system, the hospital received a fixed amount for each hospital stay: $\forall h, RH(h) = \overline{RH}$.

Finally, the constraint imposed by health authorities on the number of available beds in the hospital (L_H) is defined as follows:

$$hD(e,h,q) \leq L_H \tag{5}$$

3 The retrospective payment system

Hospital-physician interactions refers to the way the two partners behave and, more specifically, their ability (or not) to cooperate in the production of hospital stays. We investigate these two different situations by means of several equilibrium concepts.

3.1 Non-cooperative equilibrium

Within a non-cooperative framework, different equilibrium concepts can be considered. The most usual one is the Cournot equilibrium, i.e., the situation in which both players choose the actions simultaneously and, therefore, each player considers the action chosen by the other player as given when making its own decision. But one can consider the situation in which the players choose the actions sequentially. In that case, the player who chooses first (the leader) is able to influence the decision of the other player (the follower). At first, it seems difficult to know if the physician or the hospital manager is in a better position to be the leader. This will depend on the local environment and the degree of scarcity of physicians and private hospitals in a given region. In addition to Cournot equilibrium, we will also analyze (1) the Stackelberg equilibrium with the hospital manager acting as leader and (2) the Stackelberg equilibrium with the physician acting as leader.

3.1.1 Cournot equilibrium

In the case of Cournot equilibrium, physician optimization problem is given by :

$$\begin{aligned} \underset{e,h}{Max}\, \Pi^M(e,h) &= D(e,h,q)\left[RM\left(e\right) - CM(e)\right] \\ \text{s.t. } hD(e,h,q) &\leq L_H \quad (\lambda^{cp}) \end{aligned} \tag{6}$$

First-order conditions associated to this optimization program are:

$$D_e\left[RM - CM - \lambda^{cp}h\right] + D\left[RM_e - CM_e\right] = 0 \tag{7}$$

$$D_h\left[RM - CM - \lambda^{cp}h\right] - \lambda^{cp}D = 0 \tag{8}$$

If the bed constraint is not binding ($\lambda^{cp} = 0$), the physician maximizes his net income by choosing the length of stay $\widehat{h}_c$ considered as optimal by the patients ($\widehat{h}_c = \overline{h} \Longleftrightarrow D_h = 0$). The trade-off between marginal income and marginal cost leads the physician to adopt a level of effort $\widehat{e}_c$ which is higher than the one which maximizes the per-patient net income ($\widehat{e}_c > \widetilde{e} \Longleftrightarrow RM_e - CM_e < 0$).

In the case in which the bed constraint is binding ($\lambda^{cp} > 0$) conversely, it is clearly detrimental for the physician. It makes him reduce both the length of stay and effort level and has a negative impact on his net income.

Hospital optimization problem is defined as follows:

$$\begin{aligned} \underset{q}{Max}\, \Pi^H(q) &= D(e,h,q)\left[RH\left(h\right) - CH(h)\right] - c_q q \\ \text{s.t. } \quad hD(s,h,q) &\leq L_H \quad (\lambda^{ch}) \end{aligned} \tag{9}$$

leading to the following first-order condition:

$$D_q\left[RH - CH - \lambda^{ch}h\right] - c_q = 0 \tag{10}$$

If the bed constraint is non binding ($\lambda^{ch} = 0$), the hospital chooses a level of inputs $\widehat{q}_c$ such that the marginal cost of inputs, c_q, equals the marginal income per-patient stay, $D_q\left[RH - CH\right]$.

If the bed constraint is binding, the hospital's choice is completely dictated by the constraint. This corresponds to a situation in which $D_q\left[RH - CH\right] > c_q$. In this case, $\widehat{q}_c$ will be given by $hD = L_H$. The bed constraint therefore is detrimental for both hospital and physician. More generally, we can derive the following proposition:

Proposition 1 *Bed constraint imposed by health authorities destroys Cournot equilibrium uniqueness. In this situation, the one making a choice first implicitly determines his partner's choices. Therefore, there is a strong incentive either to cooperate or to act as a leader.*

Since the bed constraint is borne jointly by the two partners, the system of equations to be solved for determining the Cournot equilibrium is under-identified: five variables have to be determined $\left\{\widehat{e}_c, \widehat{h}_c, \widehat{q}_c, \lambda^{cp}, \lambda^{ch}\right\}$ with the help of four equations ((7), (8), (10), and (5)).

In the case the constraint is binding, the follower could be forced to accept the worst of the possible Cournot equilibria.

3.1.2 Stackelberg equilibrium: hospital leadership

The main problem for the hospital manager is that length of stay, i.e. the key variable for the hospital, is under physician control. By acting as a leader, the hospital manager can choose the level of inputs that will make the physician adopting the length of stay that maximizes hospital's profit. However, in the case of a non binding constraint, the only concern of the physician acting as a follower is to choose the length of stay that maximizes patients' satisfaction (see condition (8)). In this situation, the hospital manager can only affect physician's level of effort. Therefore, we should analyze two different cases, first when the constraint on the number of beds is binding or, second, when it is not.

Proposition 2 *In the case the bed constraint is binding, the hospital manager acting as leader chooses the greatest level of inputs that makes the physician adopting the longest length of stay he is willing to accept, i.e., the one maximizing patients' satisfaction* $\overline{h}$.

Since a binding constraint is characterized by $D = \frac{L_H}{h}$, the variation of the hospital's profit following a variation of the length of stay is given by:

$$\frac{d\Pi^H}{dh} = \frac{L_H}{h^2}\left[CH(h) - hCH_H\right] - \frac{dq}{dh}c_q \tag{11}$$

With $CH(h)$ being concave and null for $h = 0$, this implies that $CH(h) - hCH_H > 0$. Moreover, with respect to the bed constraint, this implies that $\frac{dq}{dh} = -\frac{D+hD_h}{hD_q} < 0$. For each positive h, we have $\frac{d\Pi^H}{dh} > 0$. But the physician when acting as follower, will never accept a length of stay higher than $\overline{h}$ the threshold beyond which patients' utility start decreasing . So, $\overline{h}$ represents the highest length of stay achievable for the hospital. In order to make the physician adopting $\overline{h}$, the hospital should lead the physician to a situation in which the physician considers the bed constraint as non-binding. For this purpose, the hospital should reduce his level of inputs. Once the bed constraint becomes no more binding for the physician, the hospital has no more interest to reduce further his input level because in this situation $D_q[RH - CH] > c_q$. The hospital then chooses the greatest input level $\widehat{q}_{lh}$ such that the physician will choose $\widehat{h}_{lh} = \overline{h}$.

In this situation, the optimization conditions are as follows:

$$D_e\,[RM - CM] + [RM_e - CM_e]\,D = 0 \tag{12}$$

$$D_h = 0 \tag{13}$$

$$hD = L_H \tag{14}$$

This situation is quite different when the bed constraint is no longer binding, since a decrease in q does not impact h. So, the hospital can only benefit from an increase of e. From condition (7), it can be shown that $\frac{de}{dq} < 0$. The optimization condition on q is then given by:

$$(D_q + \frac{de}{dq}D_e)\,[RH - CH] = c_q \tag{15}$$

Comparing conditions (10) and (15) we can see that the hospital manager chooses a level of inputs less than the one associated to Cournot equilibrium, $\widehat{q}_{lh} < \widehat{q}_c$.

3.1.3 Stackelberg equilibrium: physician leadership

Just as the aim of the hospital manager when acting as leader is to reduce its inputs and to let the physician take on the majority of the effort for increasing demand, the aim of the physician, when acting as leader, is to induce the hospital to increase its inputs to meet the positive impact on demand. Nevertheless, the hospital only increases its inputs if marginal benefit is higher than marginal costs. The hospital reaction function can then be derived from (10) and is given by:

$$\forall e, h,\ R_C(e,h) = \{q \mid D_q\,[RH - CH] = c_q\} \tag{16}$$

Given the patients' utility function, we have $\frac{dR_C}{de} = 0$ and $\frac{dR_C}{dh} = -\frac{D_q(RH_h - CH_h)}{D_{qq}(RH - CH)} > 0$. First-order conditions associated with the physician's optimization problem are the following:

$$D_e\left[RM - CM - \lambda^{lp}h\right] + [RM_e - CM_e]\,D = 0 \tag{17}$$

$$(D_h + \frac{dR_C}{dh}D_q)\left[RM - CM - \lambda^{lp}h\right] - \lambda^{lp}D = 0 \tag{18}$$

First, we analyze physician behavior when the bed constraint is not binding ($\lambda^{lp} = 0$). Since $\frac{dR_C}{dh} > 0$, a comparison between (18) and (8) concludes that physician will adopt a length of stay higher than $\overline{h}$ in order to benefit from an increase in q ($\widehat{h}_{lp} > \widehat{h}_c$ and $\widehat{q}_{lp} > \widehat{q}_c$). Compared to the Cournot equilibrium, the increase in both h and q implies an increase in demand. This increase allows the physician to reduce his level of effort (condition (17) is similar to condition (7) but is characterized now by a higher demand). The physician therefore comes closer to $\widetilde{e}$ (i.e., $\widehat{e}_c > \widehat{e}_{lp} > \widetilde{e}$).

When the bed constraint becomes binding, the mechanisms through which the physician takes advantage of its leadership are the same as in the case the constraint is not binding, but the consequences on demand are different.

Proposition 3 *When acting as leader, the physician accepts a higher length of stay in order to make the hospital increase its level of inputs. As a consequence, the physician is able to reduce his level of effort. When the bed constraint is binding, this implies a decrease in demand .*

Combining condition (17) and condition (18) when $\lambda^{lp} \neq 0$ leads to the following equation :

$$\frac{L_H}{L_H + D_h + \frac{dR_C}{dh} D_q} D_e \left[RM - CM\right] + \left[RM_e - CM_e\right] D = 0 \tag{19}$$

This equation is quite similar to the one obtained when combining condition (7) and condition (8) in the corresponding Cournot equilibrium:

$$\frac{L_H}{L_H + D_h} D_e \left[RM - CM\right] + \left[RM_e - CM_e\right] D = 0 \tag{20}$$

It is clear from the comparison of these two equations that being the leader means the physician must be aware of the impact of h on q ($\frac{dR_C}{dh} D_q$). As a consequence, the physician will be less inclined to increase his level of effort in order to increase demand: $\frac{L_H}{L_H+D_h+\frac{dR_C}{dh} D_q} < \frac{L_H}{L_H+D_h}$. Moreover, if the bed constraint is binding ($L_H = hD$) and at equilibrium we observe a higher length of stay, then the demand has to be lower. Nevertheless, even if there is an incentive towards a lower e and a higher h and q, since the presence of the bed constraint destroys Cournot equilibrium uniqueness, it remains difficult to make a direct comparison between $\left\{\widehat{e}_c, \widehat{h}_c, \widehat{q}_c\right\}$ and $\left\{\widehat{e}_{lp}, \widehat{h}_{lp}, \widehat{q}_{lp}\right\}$.

It is interesting to note that even if it is always better to be leader than follower, the hospital has more to gain from being a follower than the physician. Clearly, when the number of available beds is not binding, the hospital situation is better when the physician acts as a leader than in Cournot equilibrium, since the length of stay and the demand are higher. Similarly, when the bed constraint is binding, the physician can only take advantage from his leadership by offering a length of stay considered as more favorable by the hospital. In other words, being leader for the physician means to be aware that, to a certain extent, he could benefit from improving hospital's situation. Cooperation remains nevertheless a better way to take advantage from internalizing the externalities than trying to exert a leadership on his partner.

3.2 Cooperative equilibrium

When the couple hospital-physician decides to cooperate in order to maximize joint profits, the level of effort e, the length of stay h and the level of inputs q, are determined by solving the following optimization program:

$$\begin{aligned} \underset{e,h,q}{Max} \Pi^M + \Pi^H = & \; D(e,h,q) \left[RM\left(e\right) - CM(e) + RH\left(h\right) - CH(h) \right] - c_q q \\ & \text{s.t.} \quad hD(s,h,q) \leq L_H \quad (\lambda^{co}) \end{aligned} \tag{21}$$

First-order conditions are given by:

$$D_e \left[RM - CM + RH - CH - \lambda^{co} h \right] + \left[RM_e - CM_e \right] D = 0 \tag{22}$$

$$D_h \left[RM - CM + RH - CH - \lambda^{co} h \right] + \left[RH_h - CH_h - \lambda^{co} \right] D = 0 \tag{23}$$

$$D_q \left[RM - CM + RH - CH - \lambda^{co} h \right] - c_q = 0 \tag{24}$$

Since cooperation means that each partner makes additional efforts in order to increase joint profits, it can be shown that:

Proposition 4 *When the bed constraint is not binding, cooperative equilibrium is characterized by stronger physician effort, longer length of stay and greater level of hospital inputs compared to Cournot equilibrium.*

When the bed constraint is not binding the cooperative equilibrium is defined by conditions (22), (23), (24) with $\lambda^{co} = 0$ and the Cournot equilibrium by conditions (7), (8), (10) with $\lambda^c = 0$. Comparing conditions (23) and (8), we can observe that since $[RH_h - CH_h] > 0$ then $\widehat{h}_{co} > \overline{h} = \widehat{h}$. Furthermore, when comparing (24) with (10) we have that $[RM - CM + RH - CH] > [RH - CH]$ and then $\widehat{q}_{co} > \widehat{q}_c$. Finally, comparing (22) with (7) we have $[RM - CM + RH - CH] > [RM - CM]$ which implies $\widehat{e}_{co} > \widehat{e}_c$.

Comparison between cooperative equilibrium and Stackelberg equilibria is less obvious. What is clear is that the leader always make more effort in the cooperative equilibrium than in the Stackelberg equilibrium, especially on the variables costly for him (i.e., the level of effort for the physician and the level of inputs for the hospital). On the other hand, it is more difficult to determine whether length of stay will be longer or shorter in the cooperative equilibrium than in the Stackelberg equilibrium. For example, hospital leadership implies a length of stay remaining equal to $\overline{h}$ even if the bed constraint is binding. In the cooperative equilibrium the length of stay is higher than $\overline{h}$ for low levels of constraint ($\lambda^{co} < RH_h - CH_h$), and lower than $\overline{h}$ when the number of beds makes the constraint more binding ($\lambda^{co} > RH_h - CH_h$).

More generally, conditions defining each of the equilibrium considered allows to show that $\left\{\widehat{e}_{co}, \widehat{h}_{co}, \widehat{q}_{co}\right\} \neq \left\{\widehat{e}_{lp}, \widehat{h}_{lp}, \widehat{q}_{lp}\right\} \neq \left\{\widehat{e}_{lh}, \widehat{h}_{lh}, \widehat{q}_{lh}\right\}$ and $\left\{\widehat{e}_{co}, \widehat{h}_{co}, \widehat{q}_{co}\right\} \neq \left\{\widehat{e}_{c}, \widehat{h}_{c}, \widehat{q}_{c}\right\}$ when Cournot equilibrium is well defined (i.e. constraint is not binding). Moreover, the convexity of the optimization programs associated to the cooperative equilibrium ensures uniqueness of $\left\{\widehat{e}_{co}, \widehat{h}_{co}, \widehat{q}_{co}\right\}$. Since cooperation implies maximizing the sum of physician and hospital profits, it becomes clear that $\widehat{\Pi_{co}^{M}}+\widehat{\Pi_{co}^{H}}$ is strictly greater than $\widehat{\Pi_{lp}^{M}}+\widehat{\Pi_{lp}^{H}}$, $\widehat{\Pi_{lh}^{M}}+\widehat{\Pi_{lp}^{H}}$ and , $\widehat{\Pi_{c}^{M}}+\widehat{\Pi_{c}^{H}}$. This simply confirms, within the context of our model, the general result defining that when interactions between players are characterized by externalities (implied here by the joint production of hospital stays), cooperation is always gainful.

The ability to cooperate however raises the question of how gains associated to cooperation are to be shared. The value of cooperating rather than being leader or follower is also directly related to this question. Sharing out of gains associated to cooperation can be analyzed using Nash bargaining solutions. Although this kind of analysis is planned as an extension of the present work on hospital-physician interactions, we will not go further on this point here in order to focus more directly on the consequences of the switch from a retrospective to a prospective payment system.

4 The prospective payment system

Consequences of the implementation of a prospective payment system depend on the type of behavior adopted by the physician and the hospital manager. We analyze below these consequences for each of the equilibria identified in the previous section: Cournot, Stackelberg and cooperative. Whatever the equilibrium considered, the consequences can be divided into two categories: those directly related to a modification of the behavior involved by the switch from a retrospective to a prospective payment system, and those only related to an overall improvement or worsening of the financial conditions supporting physicians and hospital activities. Since we are only interested in the first type of consequences, we consider a change in the payment system that does not modify hospital and physician profits when the choices of e, h and q are unchanged by the switch to a prospective payment system. The fee perceived by the hospital for each stay under the new prospective payment system $\overline{RH}$ is then assumed to be identical to the mean per-patient payment received by the hospital in the previous equilibrium situation under the retrospective payment system (e.g., in the case of Cournot equilibrium, $\overline{RH} = RH(\widehat{h}_c)$).

4.1 Non-cooperative equilibrium

4.1.1 Cournot equilibrium

As already mentioned above, the Cournot equilibrium is only well defined when the bed constraint is not binding. Consequences of the introduction of a prospective payment system can only be considered in this situation.

Proposition 5 *The Cournot equilibrium, in the absence of a binding constraint, is not affected by the introduction of a prospective payment system.*

Under the prospective payment system, the optimization conditions associated to Cournot equilibrium in the absence of a binding constraint are given by:

$$D_e\left[RM - CM\right] + \left[RM_e - CM_e\right]D = 0 \tag{25}$$

$$D_h\left[RM - CM\right] = 0 \tag{26}$$

$$D_q\left[\overline{RH} - CH\right] - c_q = 0 \tag{27}$$

Since we assume $\overline{RH} = RH(\widehat{h}_c)$, conditions (25), (26) and (27) are equivalent to conditions (7), (8) and (10) with $\lambda_c = 0$. Then, $\widehat{h}_c = \overline{h} = \widehat{h}_c^p$, $\widehat{e}_c = \widehat{e}_c^p$, and $\widehat{q}_c = \widehat{q}_c^p$, where the upperscript "p" reflects imposition of the prospective payment system.

The main consequence of the prospective payment system for the hospital is the ability to reduce the length of stay and the associated costs while keeping fees unchanged. Nevertheless, the length of stay is controlled by the physician and not by the hospital. Taking advantage of the prospective payment system, therefore requires more "active" behavior from at least one of the partner than the ones associated to the Cournot equilibrium.

4.1.2 Stackelberg equilibrium: hospital leadership

As shown in the previous section, leadership for the hospital essentially means inducing the physician to increase the length of stay. Contrary to the retrospective payment system, the incentive to increase the length of stay becomes unclear under the prospective payment system.

Proposition 6 *The Hospital can only take advantage of the prospective payment system if the constraint is binding. In that case, if the advantage associated to the reduction of the costs related to the length of stay and to the increased demand are not compensated by the increase of the costs associated to the required augmentation of inputs, the hospital, acting as leader, will try to obtain from the physician a decrease in the length of stay ($\widehat{h}_{lh}^p < \widehat{h}_{lh} = \overline{h}$).*

When the bed constraint is not binding, the variation of q has no impact on the choice of the length of stay by the physician. The hospital is therefore unable to make physician reducing the length of stay.

When the constraint is binding, any increase in q leads the physician to reduce both e and h: condition (7) implies $\frac{de}{dq} < 0$ and condition (8) implies $\frac{dh}{dq} < 0$. The hospital will, however, modify its level of inputs only if its profitable. This profitability can be assessed with the help of the following expression:

$$\frac{d\Pi^H}{dh} = \frac{L_H}{h^2}\left[CH(h) - hCH_H - \overline{RH}\right] - \frac{dq}{dh}c_q \tag{28}$$

If, under the retrospective payment system, it has been shown that $\forall h, \frac{d\Pi^H}{dh} > 0$, under the prospective payment system the sign of $\frac{d\Pi^H}{dh}$ is ambiguous: $\frac{L_H}{h^2}\left[CH(h) - hCH_H - \overline{RH}\right] < 0$, but with respect to the bed constraint, it implies that, $-\frac{dq}{dh}c_q > 0$. In other words, the value for the hospital of an increase of h depends of the trade-off between the augmentation of costs related to h and the corresponding smaller demand on the one hand, and the reduction in input costs on the other hand. Two cases are to be considered:

- $\frac{d\Pi^H}{dh}$ remains positive for each $h \leq \overline{h}$. In this case the best achievable length of stay for the hospital is $\overline{h}$. The equilibrium is then characterized by $\widehat{h}^p_{lh} = \overline{h} = \widehat{h}_{lh}$, $\widehat{q}^p_{lh} = \widehat{q}_{lh}$ and $\widehat{e}^p_{lh} = \widehat{e}_{lh}$; that is, the same equilibrium as for the retrospective payment system.

- The length of stay such that $\frac{d\Pi^H}{dh} = 0$ is lower than $\overline{h}$. Compared to the retrospective payment system, the hospital manager acting as leader will increase its inputs ($\widehat{q}^p_{lh} > \widehat{q}_{lh}$) in order to obtain by the responding physician a reduction in both e and h: $\widehat{h}^p_{lh} < \widehat{h}_{lh} = \overline{h}$, $\widehat{e}^p_{lh} < \widehat{e}_{lh}$. Moreover, since $\widehat{h}^p_{lh} < \widehat{h}_{lh}$ and since the bed constraint has to be respected, we will observe an increase in demand.

It is interesting to note that the hospital can only take advantage of the prospective payment system by improving the physician situation: when the new equilibrium differs from the previous one (in the retrospective system), it is characterized by a lower level of physician effort and an increase in demand. This result is a direct consequence to the fact that the physician controls the key variable to obtain some advantages from the implementation of the prospective payment system: the length of stay.

Another element which has to be mentioned is that, in the case of a binding constraint, the reduction of the length of stay implies an increase in demand and therefore an increase of the required budget for funding the hospital and physician's activities. If the health authorities are not willing to accept such an increase, potential advantages associated to the introduction of the prospective payment system could seriously wane or even disappear.

4.1.3 Stackelberg equilibrium: physician leadership

As in the previous section, results presented below derive from the fact that, since the physician controls the length of stay (the key variable as regards prospective payment consequences), he is in a good situation to take advantage of the new payment system.

Proposition 7 *Whenever the bed constraint is or is not binding, the physician takes advantage of the prospective payment system through an increase in demand by letting the hospital benefit from a shorter length of stay. In regards to its own level of effort, he can accept an increase but only in some cases when the bed constraint is binding.*

As in the retrospective payment system, the objective of the physician, when acting as leader, is to make the hospital increase the level of its inputs in order to benefit from the corresponding increase in demand. The hospital reaction function is given by:

$$\forall e, h,\ R_C(e, h) = \{q \mid D_q\,[RH - CH] = c_q\} \tag{29}$$

Given the patients' utility function, we have now $\frac{dR_C}{de} = 0$ and $\frac{dR_C}{dh} = \frac{D_q CH_h}{D_{qq}(RH-CH)} < 0$. Contrary to the retrospective case, an increase of length of stay reduces the level of inputs that the hospital is willing to provide. First order conditions associated to the physician's optimization program are the following:

$$(D_e + \frac{dR_C}{de} D_q)\left[RM - CM - \lambda^p_{lp} h\right] + [RM_e - CM_e]\,D = 0 \tag{30}$$

$$(D_h + \frac{dR_C}{dh} D_q)\left[RM - CM - \lambda^p_{lp} h\right] - \lambda^p_{lp} D = 0 \tag{31}$$

In the case the bed constraint is not binding ($\lambda^p_{lp} = 0$), condition (31) will be satisfied only if $D_h > 0$, given that $\frac{dR_C}{dh} < 0$. So, at equilibrium, we have a length of stay shorter than the length of stay at the Cournot equilibrium and, therefore, shorter than the length of stay corresponding to the retrospective case, i.e., $\widehat{h}^p_{lp} < \overline{h} < \widehat{h}_{lp}$. Moreover, from the hospital reaction function, we can see that, at equilibrium, $\widehat{q}^p_{lp} > \widehat{q}_{lp}$. Although the variations of h and q are of different sign, the impact on demand should be positive. Otherwise, the physician could decide not to modify the length of stay when facing the new prospective system. Finally, the greater demand will let the physician providing a smaller effort $\widehat{e}^p_{lp} < \widehat{e}_{lp}$.

In the case the bed constraint is binding ($\lambda^p_{lp} > 0$), condition (31) will be satisfied only if $D_h > 0$, given that $\frac{dR_C}{dh} < 0$. Indeed, from (31) we have $\lambda^p_{lp} = \frac{(D_h + \frac{dR_C}{dh} D_q)(RM-CM)}{D + (D_h + \frac{dR_C}{dh} D_q)h} > 0$ if and only if $(D_h + \frac{dR_C}{dh} D_q) > 0$. And $(D_h + \frac{dR_C}{dh} D_q) > 0$ if and only if $D_h > 0$. Therefore, we also have the case that $\widehat{h}^p_{lp} < \overline{h} < \widehat{h}_{lp}$. Given that $\frac{dR_C}{dh} < 0$, the level of inputs provided by the hospital will be $\widehat{q}^p_{lp} > \widehat{q}_{lp}$. Moreover, given that the constraint on the number of beds should be satisfied under both the retrospective and the prospective payment system, the impact on demand of the reduction of h and the increase of q should be positive. For a constant level of $L_H = hD$, the reduction of h ($\widehat{h}^p_{lp} < \widehat{h}_{lp}$) implies a higher demand after the introduction of a prospective payment system.

Substituting the expression for λ^p_{lp} obtained from (31) in condition (30) and taking into account the constraint on the number of beds, we can rewrite (30) as follows:

$$\frac{L_H}{L_H + D_h + \frac{dR_C}{dh} D_q} D_e\,[RM - CM] + [RM_e - CM_e]\,D = 0 \tag{32}$$

Knowing the equilibrium effort of the physician, we should compare the expression above with a similar expression under the retrospective payment system. With a higher demand in the prospective case and knowing that $\frac{dR_C}{dh} < 0$, while in the retrospective case $\frac{dR_C}{dh} > 0$, the physician's level of effort at equilibrium $\widehat{e}^p_{lp}$ could be greater or smaller than $\widehat{e}_{lp}$. In either case, the physician's profit increases as a result of the introduction of the prospective payment system.

4.2 Cooperative equilibrium

The consequences of the prospective payment system on Stackelberg equilibria can be sketched out as situations in which the hospital wants to benefit from advantages associated to a reduction of lengths of stay (implying cost savings without impacting incomes). But since the length of stay is controlled by the physician, the hospital has to offer the physician an increase in demand. This kind of trade-off is no longer required when the physician and the hospital are able to cooperate.

Proposition 8 *Whenever the bed constraint is or not binding, the implementation of the prospective payment system induces a reduction of the length of stay. Contrary to the previous cases, demand only increases when the bed constraint is binding. When the constraint is not binding, the impact on demand is ambiguous.*

In the case when the hospital and the physician decide to cooperate and choose the level of effort e, the length of stay h and the level of inputs q that maximizes the joint profits, the optimization conditions are the following:

$$D_e\left[RM - CM + \overline{RH} - CH - \lambda^p_{co}h\right] + \left[RM_e - CM_e\right]D = 0 \quad (33)$$

$$D_h\left[RM - CM + \overline{RH} - CH - \lambda^p_{co}h\right] - \left[CH_h + \lambda^p_{co}\right]D = 0 \quad (34)$$

$$D_q\left[RM - CM + \overline{RH} - CH - \lambda^p_{co}h\right] - c_q = 0 \quad (35)$$

Conditions defining the cooperative equilibrium under the retrospective system (22), (23), (24) and under the retrospective payment system (33), (34), (35) differ only by the term RH_hD appearing in the left hand side of condition (34). Since RH_hD is positive and the left hand side of (34) is decreasing in h, it is clear that $\widehat{h}^p_{co} < \widehat{h}_{co}$

When the bed constraint is binding, a decrease in h is compensated by an increase in demand $(hD = L_H)$ The switch from a retrospective to a prospective system then necessary implies a increase in demand.

The situation is a slightly different when the bed constraint is not binding ($\lambda^p_{co} = 0$). The left hand side of condition (34) is negative for equilibrium values corresponding to the retrospective system $\widehat{e}_{co}$, $\widehat{h}_{co}$ and $\widehat{q}_{co}$. Therefore, to satisfy condition (34), the length of stay should be $\widehat{h}^p_{co} < \widehat{h}_c = \overline{h} < \widehat{h}_{co}$. With the reduction in h we have that CH decreases while $\overline{RH}$ remains the same. So, the term $\left[RM - CM + \overline{RH} - CH\right]$ increases. In this case, condition (35) will be satisfied only if D_q decreases, i.e., only if the level of inputs $\widehat{q}^p_{co} > \widehat{q}_{co} > \widehat{q}_c$. However, the impact on D of the reduction in h and the increase in q is ambiguous. If D decreases, condition (33) will be satisfied if the level of effort $\widehat{e}^p_{co} > \widehat{e}_{co}$. But if D increases, and depending on the increase of $\left[RM - CM + \overline{RH} - CH\right]$, the effort level satisfying condition (33) $\widehat{e}^p_{co}$ can be smaller or bigger than $\widehat{e}_{co}$.

This result derives from the fact that, in a cooperative situation, the physician does not have to obtain a direct benefit through an increase in demand for reducing the length of stay following the implementation of the prospective payment system.

5 Conclusion

The main result of this analysis is related to potential gains associated to the implementation of a prospective payment system. Although this new payment system only affects hospital fees, there are potential gains for both private hospitals and physicians working in these hospitals. These gains are involved by the possibility, under the prospective payment system, to shorten hospital stays for obtaining cost savings without suffering any income reduction. Since the length of stay is a variable under physicians' control, taking advantage of this possibility requires not only a minimum level of coordination but also that both partners have something to gain from it.

In fact, physicians are in a better position than hospital managers to benefit from the new payment system: if they consider that there is nothing to gain, the switch to the new payment system will have no impact. For example, the case in which the hospital manager is leader and the bed constraint is not binding corresponds to this situation. As regards coordination, cooperation is obviously the best way to achieve it since it ensures maximization of joint profits. Leadership of one of the two partners is nevertheless enough to obtain the minimum level of coordination required for the change in payment system to be gainful for both hospital and physicians.

Before discussing the likelihood of effects shown with our model, it has to be reminded that our results refers to a context in which average per-patient fees perceived by hospitals are not affected by the implementation of the prospective payment system. This derives from the fact that we are interested in behavioral consequences of the new system, not in consequences related to an overall improvement or worsening of reimbursement conditions provided by health authorities. It can nevertheless be claimed that these results also apply to other situations: an overall modification of reimbursement conditions does not, by itself, eliminate potential gains associated to the switch from a retrospective to a prospective payment system. Such a modification will essentially impact on the importance of these gains.

Besides issues related to reimbursement levels granted by health authorities, several arguments can be put forward to consider that potential gains associated to a prospective payment system remain limited. The first is related to the one-time nature of these gains. Once the new system is implemented, it clearly offers less margin for hospitals to increase their income: hospital income becomes only dependent of the number of patients treated and not on the length and content of stay. This is the kind of effect observed following the implementation of a prospective payment system for Medicare in USA: the slower increase in hospital costs due to a reduction of length of stay has been only temporary [See Rosko and Broyles (1987), and Antel et al. (1995)].

The second argument is that these gains are directly related to the ability to decrease the length of stay. The trend towards decreasing average length of stays in private hospitals is quite old (8.4 days in 1985, 5.0 days in 2000 for stays related to acute care[3]). Private hospitals have also largely developed ambulatory surgery (in 1998, more than 80% of the ambulatory surgeries were carried out by private for-profit hospitals[4]). As shown by our model, these trends can be related to activity constraints which creates an incentive to reduce the length of stay. Given reductions already made, even if a prospective payment system creates additional incentives, it is unclear that private hospitals will be able to significantly decrease the length of stay further. The 15% reduction in the length of stay during the first 3 years derived from Medicare experience in the early eighties (See Folland et al.(2001)) cannot be regarded as a reference point for what may occur in the French case as the period of time and the context are clearly different.

Furthermore, gains derived from the prospective payment system are, in most cases, related to an increase in demand, notably because in a non-cooperative context that is the only incentive for physicians to decrease lengths of stay. This increase in demand is clearly positive from the patients' viewpoint since it is a consequence of an improvement of their satisfaction. But, it also implies an increase in the funding level which has to be, implicitly or explicitly, accepted by health authorities.

Regarding this point, it has to be mentioned that we limited our analysis to interactions between physicians and hospital managers in the private sector. We then implicitly consider that the switch to the new payment system takes place in a stable environment. In fact, since all hospitals are concerned by the new payment system, even if the couple hospital-physician modifies its choices following the implementation of the new system, the impact on demand remains unclear. This is one of the main limitations of the analysis presented here and why we plan to extend our model.

The analysis presented here constitutes, in fact, a first step of an analysis of the consequences of the implementation of a prospective payment system in France. The first direction in which we have already begun to extend the work achieved is related to the impact of a prospective payment system on competition between public and private hospitals. Clearly, one of the main concerns of both public and private sector regarding the new payment system is related to competition issues. While private hospitals view the new payment system rather favorably if it really involves

[3]Data reported in Ecosante 2002 database. The same trend is observed in public and public-like hospitals but with a lower slope (8.7 days in 1985, 5.9 days in 2000).

[4]SAE data

more direct competition across sectors[5], public hospitals point out that specificities linked to their public status make it necessary to maintain differences in the treatment of the two sectors. The choice made by health authorities, at least initially, is maintaining differences in tariffs applicable to the two sectors. Tariffs constitute however only one side of competition, the other one is market sharing among suppliers. Regarding this second element, our analysis shows the key role played by activity constraints on the hospital-physician relationships and how these constraints lean importantly on their choices. So, the impact of the new payment system on competition between sectors not only depends on tariffs but also on its indirect consequences on activity constraints in the private sector. In other words, under a retrospective system, bed constraints and, more generally, activity constraints helped health authorities limit the rise of expenditures in the private sector. Such constraints becoming less useful under a prospective payment system, their disappearance may have an indirect but significant impact on competition across sectors.

Another extension of the model is related to the negotiation of gains associated with cooperation. Results presented here regarding cooperation confirms a well-known result: full cooperation is always the best way to maximize the sum of gains obtained by all the players in the presence of externalities. This result however gives no information on the value of cooperation for each partner. Dor and Watson (1995) addressed this question using the Nash bargaining solution. These authors showed that in order to obtain, through negotiation, outcomes identical to those corresponding to full cooperation, players must not only agree on a rule for sharing gains but they also should agree on a desirable level for each decision variable. Dor and Watson (1995) expressed doubts on the possibility of a negotiation of the level of effort made by the physician. This difficulty also clearly applies in the French case.

A third extension refers to the number of hospitals and physicians considered in our model. As in Dor and Watson (1995), our analysis is focused on a couple made of a hospital and a representative physician. One may argue than considering several physicians rather than a representative one would have been more relevant. In fact, by itself, the number of physicians working in a hospital does not modify the nature of interactions between a manager controlling hospital inputs and physicians controlling the length of stays and their own level of efforts [See Custer et al. (1990) for an analysis on hospital- physician interactions in the presence of several physicians]. On that point, it is rather the degree of scarcity of hospital facilities on the one hand, and the degree of scarcity of physicians in a given region on the other hand which are crucial regarding the ability of each partner to impose its will. Considering both hospital and physician leaderships allows us to examine the two possible extreme situations.

[5] More information on the position of private hospitals on the reform can be found at the following website : www.fhp.fr

Finally, regarding the number of physicians, it may have been interesting to make a distinction between prescribers (e.g. internists) and prescribed physicians (e.g. radiologists). Incentives associated to the introduction of a prospective payment system affecting their fees are clearly different for these two categories of physicians. However, since the prospective payment system only concerns fees paid to the hospital, making this distinction among physicians appears less crucial.

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