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Optimal Regulation of Health System with Induced Demand and *Ex post* Moral Hazard*

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ABSTRACT. – In this paper, we analyze the joint regulation of health care providers and health insurance contracts in a framework which contains both induced demand effects from physicians and *ex post* moral hazard behaviors from patients. After defining a framework where these two kinds of behaviors can be compatible, we exhibit that contrary to what we can observe in practice, a regulation that contains incentives on only one sector may be dominated by a policy-mix regulation.

Régulation optimale du système de santé dans un contexte de risque moral *ex post* et demande induite

RÉSUMÉ. – Dans cet article, nous étudions la régulation jointe du secteur de l'offre de soins et des contrats d'assurance maladie dans un cadre d'analyse comprenant à la fois des phénomènes de demande induite de la part des médecins et des comportements de risque moral *ex post* des assurés. Après avoir défini un cadre théorique permettant de réconcilier ces deux types de comportements, nous montrons que sous certaines conditions, les régulations ne contenant des incitations que d'un coté peuvent être dominées par des régulations de type *policy-mix*.

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Introduction

Whatever the institutional framework (*i.e.* public insurance or insurers in competition), the complete analysis of the health care regulation is complex. When analyzing health care regulation, three categories of actors must be taken into account: the insurers, the physicians and the policy holders who may get ill and then become patients. It is worth noticing that these different interactions are most of the time studied separately. Indeed, two strands of literature have been developed independently to explain one of the major preoccupations of economists and politicians: the increasing health expenditure and the health care overconsumption.

The first literature which explains health care overconsumption is the *ex post* moral hazard theory with the pioneering works by Arrow (1963) and Pauly (1968). This moral hazard is defined as health care overconsumption that is due to health insurance coverage, the non-insurance being implicitly taken as reference.[1] The origin of *ex post* moral hazard comes from the health risk complexity and the impossibility of establishing in health insurance contracts lump sum transfers depending on the different health states. Indeed, health risk mutualization is basically managed by reducing (or cancelling in case of complete coverage) prices paid by patients. It automatically implies a separation between the patients' willingness to pay and the social cost generated by health care, this separation obviously creating some inefficiencies.[2] Demand-side cost-sharing mechanisms such as deductibles or coinsurance rates allow us to reduce inefficiencies arising from *ex post* moral hazard problem.[3] Thus the goal of theoretical and micro-econometric studies is to determine the form of health insurance contracts and the copayments that must be applied in order to implement the optimal tradeoff between the reduction of these inefficiencies and the gain coming from risk mutualization of risk averse policy holders (Zeckhauser, 1970; Manning and Marquis, 1996; Blomqvist, 1997). It is worth noticing that demand-side cost-sharing mechanisms work only if demand for health care services exists.

The second family of literature explaining health care overconsumption is close to the supply induced demand theory and the physician-patient agency relationship. Indeed, Rice (1983) defined induced demand as the physician's ability to choose a quantity or a quality of treatment different from the one that patients would choose themselves with the same information. This theory is built on the assumption of an information asymmetry between physicians and patients. Similarly to *ex post* moral hazard theory, this literature has motivated economists to analyze physicians' remuneration schemes and their optimal regulation for the purpose of reducing inefficiencies coming from information asymmetries (see Choné and

1. See Geoffard (2000) and Bardey *et al.* (2003) for respectively an empirical and theoretical review of literature on the subject.
2. Studying inefficiencies coming from *ex post* moral hazard is out of the scope of this article. However the amplitude of inefficiencies is still a subject of debate. (See Nyman, 1999; Blomqvist, 2001; Manning and Marquis, 2001).
3. A deductible is also suggested to reduce *ex ante* moral hazard (Shavell, 1979). We do not talk too much about it because it interacts less with induced demand behaviors. See Bardey and Lesur (2005) for an analysis dealing with optimal regulation of health insurance contracts in an *ex ante* moral hazard framework.

Ma, 2007; Jack, 2004; Lesur, 2003; Bardey, 2002; Ma, 1994).[4] If, by construction, *ex post* moral hazard assumes the existence of a health care demand function, on the contrary, the induced demand theory supposes that physicians act as experts who choose the amount of health care consumption of their patients. The corollary of this theory is therefore very simple: it is inefficient to introduce coinsurance rates because they prevent risk averse policy holders from complete coverage. The health care overconsumption is coming from physicians' behaviors, only the supply-side has to be regulated.

If these two theories provide an useful and interesting emphasis on the determination of health care overconsumption, they are constructed on opposite and mutually exclusive assumptions. This opposition in their theoretical construction can probably explain their lack of intersection and the opposition in their economic policy recommendations. More interesting, the observation of several regulations applied allows us to notice that this theoretical separation is resumed in practice. In this sense, the United States example is particularly interesting. There are two main families of insurers: *Conventional Insurers* which include some copayments in their contracts with no regulation on the supply-side, and *Managed Care Organizations* (MCOs) which have no demand-side cost-sharing but that regulate physicians with prospective or mixed payments.[5] It is more difficult to interpret the French case because the public monopoly applies a coinsurance rate for some budgetary reason rather than for incentive goals. Indeed, in the French case, there is no regulation of the complementary health insurance market which generates a negative externality to the public coverage.[6] With the Juppé program, the regulation policy of the health care system has been more oriented towards the supply-side, even if this regulation does not adopt the usual incentive instruments as capitation payments (we shall use then later in the model). Regulation policy in France is rather limited to budgetary regulation.

The theoretical separation, reflected more or less among several observations of health system regulations, can be easily understood according to the distance between the respective key hypothese. However, it seems to be interesting to take into account the influence of copayment policies on the physicians' ability to induce their patients' demand. Actually, this physicians' ability certainly depends on the financial participation of patients in their health expenditure. Intuitively, it seems quite reasonable to think that it becomes more difficult for physicians to manipulate patients in their own interest when the former pay an important part of their health care consumption.

Ma and McGuire (1997) analyze a joint regulation of demand and supply of health care.[7] They decompose the physician-patient relationship in order to reconcile the two theories previously mentioned. Their analysis can be viewed as a generalization of Zeckhauser's approach[8] by modelling the physician-patient relationship in which the patient chooses his health care consumption himself but is

4. See Rochaix (1997) and Jacobzone and Rochaix (1997) for literature reviews dealing with this subject.
5. Sometime, we can observe some copayments in the MCOs' contracts but in this case it is applied in order to encourage a network policy. Actually, copayments applied by MCOs are used only when patients pay visit to physicians who do not belong to the network.
6. In this sense, we can interpret the introduction of the one euro deductible as a way to reduce this problem.
7. Eggleston (2000) analyses too this joint regulation problematic but focuses more on the risk selection dimension.
8. Zeckhauser (1970).

influenced by an effort variable of his physician. Their article reveals the interaction between the physicians remuneration schemes of and the copayments applied in health insurance contracts. However, the distribution of roles in the determination of health care consumption is complex and results are doubtful.

The goal of this article is to provide a simpler framework of the physician-patient relationship by assuming, as it is suggested in the induced demand models, that health care consumption is only decided by physicians. However, we consider that the representative physician takes into account his patient's welfare by integrating his utility in her objective function. Then, her partial altruism makes coexist in a same framework supply induced demand behaviors and *ex post* moral hazard effects. As in Ma and McGuire (1997), our approach allows us to analyze the nature of the interaction between physicians' regulation policy and the regulation of health insurance contracts. In other terms, the objective of our model is to analyze the substitutability or the complementarity of these two modes of regulation.[9] More precisely, we analyze the following questions: Is it efficient to introduce incentives to physicians through capitation payments when the health care system only includes the regulation of health insurance contracts? Is it efficient to apply some copayments in health insurance contracts when there are only incentives on the supply-side with capitation payments? What is the optimal regulation when *ex post* moral hazard and induced demand both matter: policy-mix or incentives on only one side?

This paper is organized as follows. In the first section, we expose the assumptions of the model. In the second section, we characterize the properties of the first-best allocation. In the third section, we analyze the first two questions which are very relevant in a political economy point of view. Section four concludes.

1 Assumptions and Notations

In this paper, three kinds of agents are considered: the policy holders who are defined over a continuum of health states, a representative physician who decides the health care consumption of her patients and an insurer who simultaneously mutualizes the health risk of the policy holder and decides the remuneration schemes of the physician.

1.1 Policy Holders

The policy holder's preferences are represented by the utility function $v(w,h)$. This function is increasing and concave with respect to the wealth *w*, the concavity reflecting the policy holder risk aversion (*i.e.* $v_w > 0$ and $v_{ww} < 0$). Moreover,

9. If Ma and McGuire's analysis can be interpreted as a generalization of Zeckhauser (1970), our approach is closer to the Blomqvist one.

we assume that this function satisfies the Inada conditions: $\lim_{w \to 0} v_w(w) = \infty$ and $\lim_{w \to \infty} v_w(w) = 0$. As usual, this utility function is also increasing and concave with respect to the quantity h consumed (*i.e.* $v_h > 0$ and $v_{hh} < 0$).

In order to avoid wealth effects that would complicate the analysis, we resume in this article Blomqvist's assumption[10] by supposing that v is additively separable with respect to the two arguments (*i.e.* $v_{wh} = 0$).

The *ex post* utility level of a policy holder characterized by a pathology θ is:

$$v(\theta) = v(w, h - \theta) \tag{1}$$

with a wealth w such that:

$$w = y - \pi - c(h) \tag{2}$$

where y denotes the initial wealth level.[11] The representative policy holder pays a premium[12] π and is confronted to a copayment $c(h)$ function of the health care consumption.

In order to exhibit more easily the differences with Blomqvist's analysis, we assume in a first step that the patients choose their health care consumption. Following the *ex post* moral hazard analysis, the optimality condition that determines the health care consumption is:

$$c'(h) v_w(y - \pi - c(h), h - \theta) = v_h(y - \pi - c(h), h - \theta) \tag{3}$$

This condition describes the equalization of the financial marginal cost $c'(h) v_w$ generated by the health care consumption to the patient and the marginal benefit due to his health state improvement.[13] Blomqvist's contribution is then the determination of the optimal health insurance contract by maximizing the expected utility of the policy holders (before the knowledge of the health state θ), subject to a budget balanced constraint and that, confronted with this contract, the patients choose their optimal health care consumption.[14] In this framework, Blomqvist shows that the optimal health insurance contract must be characterized by a non linear copayment scheme $c(h)$, very close to the optimal taxation results.

10. Blomqvist (1997).
11. In this article, we do not study the redistributive role that can be played by the health risk management (see Rochet (1991) for an analysis that focused on redistributive aspects). Here, we assume that policy holders have the same initial wealth.
12. Or a cotisation according to the nature of the health risk management, this point does not matter in this analysis.
13. See Cutler and Zeckhauser (2000) for more comments on this condition.
14. The public or private nature of the health risk management does not matter so much here, the budget balanced constraint being the same.

1.2 The Physician's Objective

The physician's objective is the subject of a very huge literature.[15] In this article, we retain one of the compromises that seems to be largely accepted by considering that the representative physician is characterized by a utility function containing two arguments: the financial benefit generated by her activity and the welfare of her patients.[16] This assumption captures the idea that the physician's goal is more complex than the simple profit maximization but that she stays an imperfect agent for her patients. If we resume this assumption in a supply induced demand framework, a partial degree of altruism means that the physician always choose a quantity or quality of health care different that the patients would choose themselves with the same information.

Here, we assume that the physician objective function, denoted by V, is:

$$V(h) = \gamma.T(h) + (1-\gamma).v(y - \pi - c(h), h - \theta)$$

where $T(h)$ denotes the financial benefit associated to a quantity of health care h, weighed by a coefficient γ, the patient's utility being weighed by $1-\gamma$. Choné and Ma (2007) have shown that this objective can also be viewed as a reduced form of usual physician-patient interactions' models.[17]

The first-order condition of the physician maximization program is given by:

$$c'(h)v_w(.) = v_h(.) + \frac{\gamma}{1-\gamma}T'(h)$$

The physician chooses a quantity of health care for her patient such that their marginal benefit, composed by a financial component $T'(h)$ and a marginal improvement of the health state $(1-\gamma)v_h(.)$ is equal to the marginal cost of the health care provided. This optimality condition reveals the two effects at the origin of the health care overconsumption. The first effect is generated by *ex post* moral hazard behaviors from patients. This effect would be the sole effect in game if the physician were totally altruistic ($\gamma = 0$). The second effect comes from supply induced behaviors. Obviously, it is maximal when $\gamma = 1$, when the physician only seeks to maximize her profit. In this case, there is only induced demand behavior and it cancels automatically the *ex post* moral hazard effect. This point constitutes the originality of our approach: being at the intersection of the two polar assumptions *i.e.* $\gamma \in]0,1[$, we can build a theoretical framework of induced demand that contains elements of *ex post* moral hazard. We can already remark that the physician's ability to induce demand depends on the copayment level paid by patients.

15. See the review of literature provided by McGuire (2000) to be convinced.
16. See Hammond (1987) for an analysis of the altruistic behaviors inside individual objective functions.
17. More precisely, these authors show that it can correspond to a reduced form of a bargaining process *à la Nash* between physician and patient or a reduced form of repeated interactions (see Rochaix, 1989).

2 First-Best Analysis

The goal of this article is to study both the regulation of health insurance contract and the regulation of health care market. If we assume that insurer(s) maximize(s) the policy holder's expected utility, we have:[18]

$$\max_{(c(.),T(.))} \int_{\theta} v\left(y-\pi-c\left(h\right),h-\theta\right) f\left(\theta\right) d\theta$$

Our model can be analyzed as a adverse selection problem[19] in which the principal and the agent are respectively the insurer and the physician. Any contract $\left(c\left(h\right),T\left(h\right)\right)$ posted by the insurer can be written $\left(c\left(\theta\right),T\left(\theta\right),h\left(\theta\right)\right)$.

This objective function is subject to three kinds of constraints:

- The physician's participation constraint:

(4) $$\int_{\theta} T\left(h\left(\theta\right)\right) f\left(\theta\right) d\theta \geq w_0$$

with $w_0 \geq 0$ the physician's wealth level of participation. It is worth noticing that in the contract theory jargon, it corresponds to an *ex ante* participation constraint.

- The insurer's budget constraint:

(5) $$B = \int_{\theta} \left(\pi - T\left(h\left(\theta\right)\right) - h\left(\theta\right) + c\left(h\left(\theta\right)\right)\right) f\left(\theta\right) d\theta \geq 0$$

the unitary cost of treatment being normalized to one.

- The constraint due to the physician's behavior:

(6) $$c'\left(h\left(\theta\right)\right) v_w \left(y-\pi-c\left(h\left(\theta\right)\right)\right) = v_h \left(\left(h\left(\theta\right)-\theta\right) + \frac{\gamma}{1-\gamma} T'\left(h\left(\theta\right)\right)\right)$$

Introducing Lagrange multipliers, α for the physician participation constraint and μ for the insurer's budget constraint, the first-order conditions lead to:

(7) $$v_w \left(y-\pi-c\left(\theta\right)\right) = v_h \left(h\left(\theta\right)-\theta\right) = \mu = \alpha$$

18. This approach can be justified if we consider a perfect competition between insurers. It is worth noticing that we would have the same objective function with a public monopoly in a context of costly public fund (Laffont and Tirole, 1993).
19. This section is inspired from the comments of one referee.

This last equation provides some properties of the first-best:

- The copayment $c(\theta)$ is constant.
- The final health level is independent of the disease intensity: $h-\theta=H_0$.

It follows that, under the first-best, the utility of the policy holder is constant. Properties of the remuneration schemes of the physician are obtained using (6).

PROPOSITION 1 *When a health care system is submitted to constraints (4), (5) and (6) the first-best optimum can be implemented using a two-part tariff for the physician* $\left(T''(h)=0\right)$*, composed of a capitation and a fee-for-service remuneration, and no coinsurance rate* $\left(c'(h)=0\right)$.

Proof: Since $c(\theta)$ *is constant, equation (6) leads to* $T'(h)=-\frac{1-\gamma}{\gamma}v_h(H_0)$. *One can obviously implement the first-best with* $c'(h)=0$ *by posting the following remuneration schemes for the physician:*

$$T(h)=w_0+\frac{1-\gamma}{\gamma}v_h(H_0)\left[H_0+\int_\theta \theta f(\theta)d\theta-h\right]$$

Proposition 1 shows that the first-best can be implemented using only supply-side cost-sharing and without any demand-side cost-sharing. In other terms, a policy-mix regulation is not optimal. Moreover, the first-best can be implemented through linear instruments, that is an interesting property in order to formulate policy recommendations. The slope of the physician's benefit is $-\frac{1-\gamma}{\gamma}v_h(H_0)$ and is increasing with γ: the more a physician is altruistic, the more important is the supply-side cost-sharing.

However, such a remuneration scheme can be faced by a problem of observation of h if $T'(h)<-1$.[20] If the supply-side cost-sharing exceeds the marginal cost of health care, it corresponds to the case where the physician has to pay a tax on the health care provided. In the next section, we restrict the set of contracts and impose the constraint $T'(h)\geq -1$, that can be interpreted in a large sense as a collusion-proof constraint. In this paper, we call it the health care imperfect observability constraint.

3 Is a Policy-Mix Regulation Optimal?

In order to provide insightful conclusions, we restrict our analysis to linear instruments. The optimal linear regulation under the health care imperfect observability constraint is analyzed in 3.1. Then, we study in 3.2 the introduction of a capitation in a demand-side regulated health-care.

20. It is worth noticing that it is the hypothesis usually done in the *ex post* moral hazard models: the insurers cannot observe the health state but can observe the health care amount.

3.1 Optimal Linear Regulation under Health Care Imperfect Observability

The analysis of the above model with linear instruments requires to define some notations:

- the copayment mechanism *c(h)* becomes $c.h$,
- the physician's scheme of remuneration $T(h)$ is restricted to $K+(p-1).h$, where K denotes a capitation level whereas p is the fee-for-service price. Using these notations, the health care imperfect observability required $p \geq 0$.

Then, the insurer's program becomes:

(8) $$\max_{c,p,K,\pi} V = \int_\theta v(y-\pi-c.h, h-\theta) f(\theta) d\theta$$

s.t.

(9) $$K+(p-1)H \geq w_0 \qquad (\alpha)$$

(10) $$\pi - K - (p-c)H \geq 0 \quad (\mu)$$

(11) $$p \geq 0 \quad (\beta)$$

(12) $$cv_w(y-\pi-c.h) = v_h(h-\theta) + (p-1)\frac{\gamma}{1-\gamma}$$

where $H = \int_\theta h(\theta) f(\theta) d\theta$ stands for the aggregated health care consumption.

Before solving this optimization program, it is worth noticing that the health care consumption h that maximizes the physician's objective function depends on the health state θ, the premium π, the copayment c and the fee-for-service price p. The total differentiation of the physician's optimality condition (12) leads to:

$$\left(v_{hh} + c^2 v_{ww}\right) dh = \left(v_w - chv_{ww}\right) dc - cv_{ww} d\pi - \frac{\gamma}{1-\gamma} dp + v_{hh} d\theta$$

Using the assumptions on the first and second-derivatives of v, we obtain that:

$$\frac{\partial h}{\partial c} < 0, \frac{\partial h}{\partial \pi} \leq 0 \text{ and } \frac{\partial h}{\partial p}, \frac{\partial h}{\partial \theta} > 0$$

The sign of the first derivatives stays identical at the aggregated level:

$$\frac{\partial H}{\partial c} < 0, \frac{\partial H}{\partial \pi} \leq 0 \text{ and } \frac{\partial H}{\partial p} > 0$$

The health care expenditures are increasing with the fee-for-service price and are decreasing with the coinsurance rate and the premium paid. This wealth effect is rarely noticed in the literature dealing with *ex post* moral hazard. It implies that there exist a feed back effect due to the premium increase generated by *ex post* moral hazard behaviors that limits its amplitude.[21]

Properties of the optimum are derived from the analysis of the first-order conditions of this program and are summarized in the following proposition.

PROPOSITION 2. *If we take into account the health care imperfect observability (11), the optimal linear regulation adopts the following form:*

If $\gamma \geq \frac{v_h(H_0)}{1+v_h(h_0)}$, *the optimal linear regulation leads to the first-best allocation with* $c=0$, $p=1-\frac{1-\gamma}{\gamma}v_h\left(H_0\right)\geq 0$ *and* $K>0$.

If $\gamma < \frac{v_h(H_0)}{1+v_h(h_0)}$, *the optimal regulation is a pure capitation scheme for the physician* $\left(p=0\right)$ *and a positive coinsurance rate* $\left(c>0\right)$.

Proof: See appendix.

Proposition 2 shows that the first-best can be implemented if the physician is not too altruistic. If it is not the case, the second-best optimum is a policy-mix regulation including a pure capitation scheme and a copayment. Proposition 2 also shows that it is never optimal to associate a fee-for-service payment for a physician with a positive coinsurance rate. This proposition also provides a simple policy recommendation: whatever the relative weight of supply-induced demand and ex-post moral hazard, one has to regulate the supply-side (the physician) before the demand-side (the patients).[22]

Regulators are often constrained for political or historical reasons in the set of instruments they can use in order to regulate the health-care system. For instance, it is often difficult to introduce demand-side regulation in Beveridgian systems, that means that the regulator is faced by the constraint $c=0$. If a health-care system is optimally regulated under the constraint $c=0$, proposition 2 can be interpreted as follows: if the optimal regulation (under $c=0$) is a two-part tariff (*i.e.* includes a fee-for service remuneration), then the constraint $c=0$ is not binding and it would not be efficient to introduce any demand-side regulation. Therefore, in this case, one can conclude that it is not interesting to try to convince people to accept a demand-side regulation. However, if the optimal regulation (under $c=0$) is a pure capitation scheme, then the constraint $c=0$ is binding and introducing a positive coinsurance rate would be efficient.

The next section investigates the symmetrical situation in which the regulator cannot use any capitation remuneration.

21. This effect is explained in Flochel and Rey (2004).
22. This property may come from the assumption that the physician's risk aversion is null and the *ex ante* participation constraint of the physician.

3.2 Introduction of a Capitation Payment in a Pure Demand-Side Regulation

In order to determine if it is efficient to introduce incentives in the physician's scheme of remuneration in a system including only regulation of health care demand (*i.e.* a positive coinsurance rate), let us consider the initial situation: p, c and π are optimally chosen for a capitation level K equal to zero. In this section, we explore whether it is efficient to introduce a capitation in this health-care system.

Without any capitation, the participation constraint of the physician implies that the fee-for service rate p is over the marginal cost of health care $(p \geq 1)$. Therefore, we can write the insurer's program as follows:

$$\max_{p,c,\pi} V = \int_{\theta} v(y-\pi-c.h, h-\theta) f(\theta) d\theta$$

$$\text{s.t. } K + (p-1)H \geq w_0 \quad (\alpha)$$

$$\pi - K - (p-c)H \geq 0 \quad (\mu)$$

Denoting by L the lagrangian function of this program, the question is then to determine the sign of $\frac{\partial L}{\partial K}$ when $\frac{\partial L}{\partial p} = \frac{\partial L}{\partial c} = \frac{\partial L}{\partial \pi} = 0$. The partial derivative of the lagrangian function with respect to K is:

$$\frac{\partial L}{\partial K} = \alpha - \mu$$

In order to find the sign of $\alpha - \mu$, we use the first-order condition $\frac{\partial L}{\partial p} = 0$:

$$\frac{\partial L}{\partial p} = \left[(\alpha-\mu)(p-1) - \frac{\gamma}{1-\gamma}(p-1) + \mu(c-1)\right]\frac{\partial H}{\partial p} + (\alpha-\mu)H = 0$$

Rearranging the terms of this last equation, we find:

(13) $$\alpha - \mu = \frac{\mu(1-c) + \frac{\gamma}{1-\gamma}(p-1)}{(p-1)\frac{\partial H}{\partial p} + H} \frac{\partial H}{\partial p} > 0$$

Using this equation, we get the following proposition.

PROPOSITION 3. *When a health care system is optimally regulated using only a coinsurance rate and a positive net fee-for-service rate, it is efficient to introduce some capitation payment* i.e. $K > 0$.

Without any capitation, the fee-for-service rate gives incentives to the physician to induce demand. Introduction of a capitation permits to lower the fee-for-service rate and explains the result of proposition 3.

4 Conclusion

We have shown that a two-part supply-side regulation using a capitation and a fee-for service is sufficient to implement the first-best optimum. Nevertheless, this optimal regulation may imply a negative value of the unit price paid to the physician.

Taking into account this constraint, we have shown that the optimal linear regulation may be a policy mix requiring incentives on both sides. We also have shown that a regulation including a fee-for-service and a coinsurance rate is never optimal. This result is in opposition with what we can observe in a lot of health care systems.

This analysis can be completed and extended in several directions. The most natural extension is to determine the optimal regulation in a non-linear framework. It would be also interesting to provide some static comparative results about the physician's altruism degree and to determine if the different instruments are monotonic with respect to the altruism parameter.

Jack (2004) and Choné and Ma (2007) studied the optimal regulation of the health care supply side by considering that the physician's altruism as an adverse selection variable. Then, it would be interesting to combine this kind of analysis in our framework in order to analyze the optimality of policy-mix in this multidimensional adverse selection context.

Moreover, we have considered in this article one representative physician, so characterized by one altruism degree. In order to totally capture the essence of induced demand effect, in particular the link with the medical density, it would be interesting to endogeineize the physicians' altruism according to the intensity of the competition in health care market.

To finish, we assumed that policy holders' utility function is additively separable in order to avoid too much complicated wealth effects. However, it would be interesting to analyze the effect of correlation between health state and wealth on the optimal regulations.

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Appendix

A *Proof of Proposition 2*

The first-order derivatives of the Lagrangian function, denoted by L, are:

$$\frac{\partial L}{\partial c}=\left[(p-1)\left(\alpha-\frac{\gamma}{1-\gamma}\right)-\mu(p-c)\right]\frac{\partial H}{\partial c}+\mu H-\int_{\theta} hv_w f(\theta)d\theta \tag{14}$$

$$\frac{\partial L}{\partial p}=\left[(p-1)\left(\alpha-\frac{\gamma}{1-\gamma}\right)-\mu(p-c)\right]\frac{\partial H}{\partial p}+(\alpha-\mu)H+\beta \tag{15}$$

$$\frac{\partial L}{\partial K}=\alpha-\mu \tag{16}$$

$$\frac{\partial L}{\partial \pi}=\left[(p-1)\left(\alpha-\frac{\gamma}{1-\gamma}\right)-\mu(p-c)\right]\frac{\partial H}{\partial \pi}+\mu-\int_{\theta} v_w f(\theta)d\theta \tag{17}$$

By equalizing (16) to zero, we have $\alpha=\mu$. Moreover, by equalizing (15) to zero, we obtain:

$$\beta=\left[\frac{\gamma}{1-\gamma}(p-1)+\mu(1-c)\right]\frac{\partial H}{\partial p} \tag{18}$$

The first-order condition related to (17) leads to:

$$\mu=\int_{\theta} v_w f(\theta)d\theta+\beta\frac{\frac{\partial H}{\partial \pi}}{\frac{\partial H}{\partial p}} \tag{19}$$

The lagrangian multiplier is equal to the weighted sum of the marginal utility of wealth over the patients reduced by the feed-back effect of the premium on the health care consumption.

Finally, the condition corresponding to $\frac{\partial L}{\partial c}=0$ can be written:

$$\beta\frac{H\frac{\partial H}{\partial \pi}-\frac{\partial H}{\partial c}}{\frac{\partial H}{\partial p}}=\int_{\theta} hv_w f(\theta)d\theta-H\int_{\theta} v_w f(\theta)d\theta$$
$$=\mathrm{Cov}(h,v_w)$$

The right-hand side of this last equation has the following properties:

- If $c=0$, v_w is constant and then $\mathrm{Cov}(h,v_w)=0$.
- If $c>0$, v_w is strictly increasing with *h*. Moreover, *h* has non atomistic distribution since $\frac{\partial h}{\partial \theta}>0$. Therefore, v_w and *h* are positively correlated and $\mathrm{Cov}(h,v_w)>0$.

Now, we can show that $c=0 \Leftrightarrow \beta=0$:

- If $\beta=0$, then $\mathrm{Cov}(h,v_w)=0$ and therefore $c=0$.
- If $c=0$, then $\frac{\partial h}{\partial \pi}=0$ for any θ and $\frac{\partial H}{\partial \pi}=0$, that means the feed-back effect is null. Therefore, it comes that $\frac{H\frac{\partial H}{\partial \pi}-\frac{\partial H}{\partial c}}{\frac{\partial H}{\partial p}}>0$. Since $c=0$, one has $\mathrm{Cov}(h,v_w)=0$. It follows that $\beta=0$.

First, we analyze the case $(\beta=0,c=0)$. Equation (19) becomes $\mu=v_w(y-\pi)$. From (15), one gets

$$p-1=-\frac{1-\gamma}{\gamma}v_w$$

From (12) one has $v_h=v_w$. Since $\beta=0$, we have $p\geq 0$, that leads to the following constraint

$$\frac{\gamma}{1-\gamma}\geq v_h$$

The case $(\beta>0,c>0)$ implies that $p=0$. Equalizing (17) to zero leads to:

$$\mu\left[1-(1-c)\frac{\partial H}{\partial \pi}\right]=\int_\theta v_w f(\theta)d\theta-\frac{\gamma}{1-\gamma}\frac{\partial H}{\partial \pi}$$

The first-order condition associated with (14) can be written:

$$\mu\left[H-(1-c)\frac{\partial H}{\partial c}\right]=\int_\theta h v_w f(\theta)d\theta-\frac{\gamma}{1-\gamma}\frac{\partial H}{\partial c}$$

Using these two last equations, we obtain an implicit expression of *c*:

$$\left(H\frac{\partial H}{\partial \pi}-\frac{\partial H}{\partial c}\right)\int_\theta (v_w-v_h)f(\theta)d\theta=\left(1-(1-c)\frac{\partial H}{\partial \pi}\right)\mathrm{Cov}(h,v_w)$$