Optimal Regulation of Specialized Medical Care in a Mixed System[1]

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November 8, 2000

[1] I am very grateful to Inés Macho-Stadler for her help and support. I also would like to thank Paula González, Carmen Matutes, Jorge Mestre, Pau Olivella, David Pérez-Castrillo and Angel M. Vera for their helpful comments. Financial support from the Generalitat de Catalunya (grant 1998FI 00020) and from the Spanish Ministry of Education (project DGES PB 97-0181) is gratefully acknowledged. All remaining errors are my own responsability.

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Abstract

We study the optimal public intervention in setting minimum standards of formation for specialized medical care. The abilities the physicians obtain by means of their training allow them to improve their performance as providers of cure and earn some monopoly rents. Our aim is to characterize the most efficient regulation in this field taking into account different regulatory frameworks. We find that the existing situation in some countries, in which the amount of specialization is controlled, and the costs of this process of specialization are publicly financed, can be supported as the best possible intervention.

JEL Classification: D80, I11, I18, L51.

Keywords: Specialized Medical Care, Mixed Systems, Regulation.

1 Introduction

According to the definition given by the Modern English Dictionary, a specialist is: "*one who devotes himself to a particular branch of a science, art or profession; authority in one particular subject*". This definition can be directly applied to the case of medical practice; the physicians pass through a highly requiring process of training prior to the execution of their work, and this training gives them a particular ability to perform their task. The formation the specialists receive increases the quality of the services they offer. It makes it more likely that they can heal the disease treated.

In this paper we analyze the rationality for regulating the formation of specialized physicians, considering both, the social welfare and the aspect of monopoly power that their knowledge gives them. Our aim is to analyze the efficiency of the existing regulation in some countries.

To better understand the problem that we deal with, we first explain the steps that have to be taken to become a specialized physician in most countries. After the undergraduate studies of Medicine, a selection process is made among those who have their bachelor degree. In Spain, for example, those who perform better have priority to choose their field of specialization. Then the real specialized training starts. This phase is mainly made in hospitals where the individuals combine both theoretical learning with the real treatment of diseases. In Spain the program in which the physicians are formed is called MIR ("Médico Interno Residente", i.e., "Internal Resident Physician"), in most OECD countries the process of specialization follows a similar pattern.

There are two important elements of these specialization programs that we want to highlight because they are the motivation for our analysis. On the one hand, we want to emphasize that the "amount of specialization" required to become a specialized physician is completely regulated, each speciality has its own fixed requirements and no one with less than the required training on his field is allowed to work as a specialist; in fact, recently there has been a lot of controversity because the Spanish government is studying the possibility of letting some physicians who have not undertaken the official process of specialization, but have followed alternative qualification programs, to perform as "specialists".

On the other hand, it is important to notice the high subsidies that exist for specialized medical education, aspect that was considered as a “remarkable feature” of the market for medical care in the early work by Arrow [1]. Those physicians who enter the program are paid a wage all the way through their process of training. Notice that this system supposes that not only the direct costs of specialization are subsidized (the physicians do not pay for the training they receive); their opportunity costs (or at least a share of these costs) are also covered, as they earn a wage while they are being formed as specialists.

To sum up, we are interested in the situation in which a minimal amount of specialization is fixed by regulation (in fact, this can be understood as the implementation of a minimum quality standard), and its associated costs are subsidized. The existence of this kind of regulation can be supported by the consideration of medical care as a “social good” or as Pauly [2] says, as an “object of social concern” deserving a special treatment. Nevertheless, we want to study the impact of the regulation on the market interaction and on the appropriation of consumers' surplus by the specialized physicians. We consider the value of specialization as generating welfare, but also as an investment that gives monopoly power to the specialist. To introduce both aspects in the model, we consider a mixed public-private system of provision of health care, where the specialized physicians are providers on the two sides: they work for the public system, but they also offer their services as private specialists. For a general presentation of the alternative systems of provision of health care see Besley and Gouveia [3].

For the role of health in the social welfare, we concentrate on the patients' health conditions. We assume that the patients face one disease, and although they have a guess, they cannot be sure about the specific type they suffer. The patients have two possibilities: they can decide to go to the public health system, and face no pecuniary costs (we assume there is no copayment for simplicity, but the analysis can be extended to include this possibility without altering the qualitative results), but in this case they have to visit compulsorily the general practitioner. This physician acts as a filter (in the literature, gatekeeper) by sending to the specialist only those patients who need it. The general practitioner also has an important role in the elimination of the uncertainty, because he recognizes the type of illness and recommends the appropriate specialist. The other possibility the patients have is to go directly to a private specialist and pay the fee he sets. In this case, they may incur in an additional cost associated with misrecognizing the symptoms and choosing the wrong doctor. The model defined this way, replicates the actual situation in countries like Italy or Spain.

We will assume that the specialists' work in the public system is fully regulated. On the contrary, we consider that they have control over their services as private providers. In this decision we will assume that the physicians act corporately and therefore there is not price competition among them. This brings to place the importance of the *medical associations*. These associations not only offer the possibility to undertake "proficiency" courses, or as diffusers of new advances and recommendations, but also seem to have an important role in the determination of the pricing policy. This view is supported for example by Zweifel and Eichenberger [4], who analyze the importance of corporatism in medicine. They argue that the main aim of the *medical associations* is collusive, they try to protect the physicians' earnings, through the control of prices and quantities.

The main result we obtain is that, under the plausible assumption that the physicians choose the amount of private demand they serve, the optimal regulation consists of a centralized selection of the level of specialization and a complete public payment of the associated costs of formation. We also characterize the opposite impact of the presence of uncertainty on the specialization choice, for the physicians and for the regulator. This allows us to spot the possible presence of overspecialization in the scenario where the specialists are allowed to select their level of qualification.

The existing literature on this topic is scarce because, although an enormous amount of research on quality regulation has been undertaken, hardly any of those papers addresses the question of the physicians quality, understood as their degree of specialization. Rizzo and Sindlear [5] consider the regulation of the physicians services in a model with multiple regulatory agencies. They study the possible presence of coordination failures among the agencies and their impact on welfare. Other papers, like Paul [6], try to test empirically the effects on the quality of the provision of medical services of the adoption of licensure laws. He states that such regulations seem to be driven more by the interest of the physicians in the protection of their high returns, than by an attempt to raise the quality of the services given. His model does not enter in conflict with our analysis as we will not consider licensing but the acquisition of the quality required to perform their task.

Wolinsky [7] studies the effects of information asymmetries in a market with experts, and explicitly quotes the specialized provision of medical care as one of that markets. He analyzes the strategic behavior of the providers and the optimal response of the consumers in a setting with costly searching. He specifically focuses in two scenarios, one with reputation concerns, and other one with experts' liability. Although the spirit of the model is very close to ours, we do not deal with strategic incentives in the physicians' decisions, while we concentrate on the optimal public intervention in the market.

Specialization can also be understood as a quality choice. The general effects of the monopoly power in the quality choice are studied in the classic work by Mussa and Rossen [8]. They show how a monopolist will have incentives to serve less consumers as compared to the competitive solution, and that it will do it at a lower than the competitive quality. This distortion is also present in our work although differently due to the special nature of the good exchanged in market for medical care, where the patients buy one unit (of medical services) and only ask for more if this first unit does not heal them. Besanko *et al.* [9] compare different remedies to the quality distortion of the monopoly situation. They find that the introduction by the regulator of *Minimum Quality Standards* will generate the exclusion of more consumers from the market, and that its welfare effects are ambiguous. Constantatos and Perrakis [10] also study the effects of Minimum Quality Standards but in a sequential setting, where the firms have to choose first whether to enter the market or not. They show that the welfare effects of the quality regulation depend crucially on the timing of the quality decision with respect to the entry one. In our model the sequentiality is also present, although in a different way, because the physicians are already established, but they make their decisions after the regulator's choice.

Finally, specialization can also be seen from a *technologic perspective*, considering that the level of specialization is in fact a technology choice. This approach is taken by Barros [11], but his aim is different from ours. He shows how inefficiencies in technology adoption may result from intermediate technology providers' decisions (aspect that we do not treat here).

The rest of the paper is organized as follows. In Section 2 we present the model. In Section 3, we develop the analysis of the optimal regulation under different scenarios. Finally, Section 4 concludes by remarking the contributions of this article, its shortcomings and the room for future research on the topic. All proofs are in the appendix.

2 The Model

There are three sets of agents in this economy: a continuum of potential patients, the physicians and the regulator. All are risk neutral.

The size of the population of potential patients is normalized to one. This population is homogeneous except for their health status, that is defined by two aspects, severity and type of illness. Their utility function is defined in terms of wealth (Y), and on the health loss.

The patients suffer one of two specific types of diseases (that for simplicity we consider ex-ante equally probable). The severity of the diseases is measured by x, and it is distributed according to a density function $f(x)$ defined on $[0, 1]$, that for convenience we assume to be uniform. This severity variable reflects not only the difficulty to be healed but also the disutility (measured in monetary terms) that the patients face when they are ill. Finally, we assume they are perfectly aware that they are ill, and perceive their severity (the actual realization of x). However, the patients do not perfectly recognize the type of illness they suffer. Specifically, we assume that when they are ill, they misrecognize their symptoms with a given probability $\alpha \in [0, \frac{1}{2})$. The interpretation of this "mistake probability" is the following: the signal the agents receive when they are ill has to be informative, hence if ex-ante the two illnesses were equally likely, now the patients must have a more accurate prediction of the type of their disease. However, this perception may not be perfect, thus there exists a probability of misrecognizing the type. Notice, that this assumption tries to capture the fact that certain diseases have very similar symptoms, for instance, a headache can be caused by a vision problem or be related with the brain, a pain in the back can be muscular or caused by the vertebrae.

In our economy two different types of physicians coexist. On the one hand, there are General Practitioners, (GP's hereinafter) who have a low degree of specialization in each field, but who can treat patients of every possible kind of illness. On the other hand, the specialists have a more specific training on their field, but are not prepared to treat patients with other diseases. In the model by Wolinsky [7], the low specialized providers (the equivalent to the GP's here), do not have the advantage of being prepared to offer a wider range of services than the high qualified specialists.

Notice that due to the fact that we have assumed that the patients make mistakes when assessing which disease they suffer, the GP's are not simply less qualified physicians. When they see a patient (no matter the type of illness she has) they will not only treat her up to their qualification, but also they will send her to the correct specialist, vanishing the uncertainty about the kind of disease. Finally, as we are interested in the behavior of the specialists, we will consider the GP's as completely passive agents. In other models of GP's versus specialists, the specialized provision of health care is considered passive, because these models study the optimal referral policy and its impact on the diagnosis effort of the GP's, (see for example García-Mariñoso and Jelovac [12]).

There is a minimum level of "quality" that all specialists have. This minimum level of qualification is assumed to be obtained prior to the starting point of the model. It coincides with the specialization of the general practitioners in this specific field, and will be represented by g. The value of g cannot be very high, for analytical convenience, we specifically assume $g \leq \frac{1}{2}$. The specialized physicians incur in costs to obtain a higher ability than the GP's. The specialization they get is denoted by $s \in (g, 1)$.

We assume that the costs of specialization are linear, with parameter $k > 0$. We want to study a mixed system, where private provision exists, therefore we will define the upper bound for the domain of k, hereinafter $\bar{k}$, as the maximum value for which the specialists will privately offer their services. This upper bound will depend on the level of uncertainty and will be explicitly computed in the next section. As we argued in the introduction, we will treat physicians as a perfectly integrated collective, therefore, we will be interested in the aggregate costs of specialization. We will introduce the idea of capacity in order to reflect the fact that the higher the proportion of patients treated, the more specialists will be needed, by writing the costs per-patient:

$$k(s - g). \tag{1}$$

The ability to heal is represented in our model by the level of specialization. The "healing technology" is the following. For a given severity $x \in [0, 1]$, a physician with a specialization $z \in [0, 1]$, will perform the following cure (to a patient whose disease is of the type for which the physician was trained):

If $x \leq z$, the patient will recover her health loss x.

If $x > z$, the patient will have a partial healing, recovering z.

The concept of partial healing deserves some explanation. We try to capture here the fact that, even if the physician can not provide a cure, the agent benefits from analgesics or other symptomatic treatments that will make her suffer a lower health loss and therefore gain some life quality. Another way to interpret this assumption is that, even if the physician is not able to cure the patient, he can give her an ill leave, allowing the patient to receive the illness subsidy.

The patients have to decide to which health system demand their treatment. They have two possibilities: the public system, and the private one.

In the public health system the patients incur in no pecuniary costs, but they are compelled to make a first visit to the GP. If they need to receive specialized care (that is, if $x > g$), they will be sent to the appropriate specialist by the GP, but there is a cost associated with receiving treatment in a second visit. We will make this explicit by assuming that the patient will only be able to recover a fraction $(1 - \delta)$ of the health loss that she did not recover in her visit to the general practitioner. Thus, a patient with severity $x > g$ will receive the following additional benefit from the public specialist:

$$\begin{array}{ll} (1-\delta)(x-g) & \text{if } x \leq s \\ (1-\delta)(s-g) & \text{if } x > s. \end{array} \tag{2}$$

That is, if $x \leq s$ the specialist will have the qualification required to fully cure the disease, but the patient will not recover all her health as she will incur in the delay costs (a fraction δ). Otherwise, (i.e. if $x > s$) the patient will suffer a double cost, first because the physician's specialization is not enough to fully heal her, and on the other because of the waiting costs δ.

If the patient chooses to go to a private supplier, she will directly visit a specialist, but, she is uncertain about the specialist she needs to see. Hence, with a probability α the patient will choose wrongly. If this is the case, she will have to make a second visit, and incur in delay costs (a fraction δ, defined as above). In addition to this, the patient will have to pay the fee the physician sets, that we will denote by w. In order to keep the model tractable, we assume that the fee is paid only once. The patient has to pay for the treatment she receives and therefore she makes no payment if she sees a doctor that does not treat her.

In this case a patient with severity x receives the following expected health benefit from the private specialist:

$$\begin{aligned} (1-\alpha)x + \alpha(1-\delta)x \qquad & \text{if } x \leq s \\ (1-\alpha)s + \alpha(1-\delta)s \qquad & \text{if } x > s. \end{aligned} \tag{3}$$

The health benefits are undermined by the delay costs associated with the imperfect knowledge of the patients, and when the severity of the disease exceeds the qualification of the physician, due to a lack of specialization.

It is important to notice that the treatment possibilities we have shown are only reasonable for non-urgent illnesses, because otherwise the patient's access to the medical treatment is made through the emergency rooms and no such "double visit" exists. This fact makes that although ex-ante we did not impose any restriction on the value of δ ($\delta \in (0,1)$), we should be constrained to consider only not very high values. The reason is that this fraction captures, in some sense, the urgency of the disease, understood as the need to receive treatment soon to avoid having a great health loss. Therefore, the model we are presenting is constructed to deal only with non-urgent diseases.

With these healing possibilities, we can now define the utility that a patient with severity x will have after she has received medical treatment. Denoting by $EU_{pub}(\cdot)$ the expected utility obtained from the public system and $EU_{pri}(\cdot)$ the one obtained from the private, we have, after simplification:

$$EU_{pub}(x,g,s,\delta,\alpha) = \begin{cases} Y \text{ if } x \leq g \\ Y - \delta(x-g) \text{ if } x \in (g,s] \\ Y - (x - s + \delta(s-g)) \text{ if } x > s \end{cases} \tag{4}$$

$$EU_{pri}(x,g,s,\delta,\alpha,w) = \begin{cases} Y - \delta\alpha x - w \text{ if } x \leq s \\ Y - (x - s + \delta\alpha s) - w \text{ if } x > s. \end{cases}$$

Both functions, $EU_{pub}(x,g,s,\delta,\alpha)$ and $EU_{pri}(x,g,s,\delta,\alpha,w)$, are continuous and decreasing in x. They are parallel for $x > s$. The patient will choose the health care provider in order to maximize her expected utility, this allows us to characterize the demand addressed to the private health system in terms of the patient that is indifferent between the two systems ($\tilde{x}$). Denote:

$$\tilde{x} = \frac{g}{1-\alpha} + \frac{w}{\delta(1-\alpha)}. \tag{5}$$

Lemma 1 *The expected demand for private health care on each of the two specialities is:*

$$D(\tilde{x}) = \begin{cases} \frac{1}{2}(1-\tilde{x}) & \textit{if } \tilde{x} \leq s \\ 0 & \textit{otherwise.} \end{cases} \tag{6}$$

The demand for private specialized care is increasing on the delay costs (δ); it is decreasing on the qualification of the general practitioners (g), on the uncertainty (α), and on the fee (w).

In the previous lemma we defined the demand addressed to the private system by means of the indifferent agent. Denoting by $w(\tilde{x})$ the wage that a patient with severity $\tilde{x}$ is willing to pay to obtain direct access to the specialized medical care, the condition we found in terms of quantities can be rewritten as follows:

$$\tilde{x} = \frac{g}{1-\alpha} + \frac{w}{\delta(1-\alpha)} \Longleftrightarrow w(\tilde{x}) \equiv \delta\left((1-\alpha)\,\tilde{x} - g\right). \tag{7}$$

We now define the specialists' profit function. As we assume the physicians to be a fully integrated collective, their objective function will include the revenues from both specialities, this possibility of collusion among the providers of medical services is also present in the work by Gravelle [13]. In addition, the specialists receive revenues both, from the patients they treat in the public system, and from their work as private suppliers. Denoting by Π_{pub} the profits they receive for their work in the public system, and by Π_{pri} the ones from their private practice, their expected profit function is as follows:

$$E\Pi(s,\tilde{x}) = \Pi_{pub} + \Pi_{pri} = \Pi_{pub} + 2D(\tilde{x})\left[w(\tilde{x}) - k(s-g)\right]. \tag{8}$$

As we said in the introduction, we take as a basis for our study the Spanish case. In Spain the public physicians do not earn in a pay-per-visit basis, hence the public part of their revenues is independent of the demand they serve as private providers. We assume that its value is determined prior to the starting point of our model, and therefore we take it as exogenous. If we substitute (6) and (7) into the expression of $E\Pi(s,\tilde{x})$ and rearrange terms, we have:

$$E\Pi(s,\tilde{x}) = \begin{cases} \Pi_{pub} + (1-\tilde{x})[\delta((1-\alpha)\tilde{x} - g) - k(s-g)] \text{ if } \tilde{x} \leq s \\ \Pi_{pub} \text{ otherwise.} \end{cases} \quad (9)$$

In order to ensure that the physicians will offer their services as private providers, we need to consider their participation constraint (PC), formally:

$$\begin{aligned} \Pi_{pri} &\geq 0 \Rightarrow w(\tilde{x}) \geq k(s-g) \Rightarrow \delta((1-\alpha)\tilde{x} - g) \geq k(s-g) \Rightarrow \\ \tilde{x} &\geq \frac{g}{1-\alpha} + \frac{k(s-g)}{\delta(1-\alpha)}. \end{aligned} \quad (10)$$

Finally, we will define the objective function of the regulator who is interested in the maximization of total surplus, defined as the sum of expected consumers' surplus plus physicians' expected profits. We assume that there does not exist any extra cost in raising public funds. We introduce this assumption only to keep the model tractable, moreover the qualitative results would not change in the presence of these costs provided its value is reasonably low. The formal expression of the regulator's objective function is:

$$TS(s,\tilde{x}) = \begin{cases} E\Pi(s,\tilde{x}) + Y - \int_g^{\tilde{x}} \delta(x-g)dx - \int_{\tilde{x}}^s [\delta((1-\alpha)\tilde{x} - g) + \alpha\delta x]\, dx \\ -\int_s^1 [\delta((1-\alpha)\tilde{x} - g) + \alpha\delta s + x - s]dx - (\tilde{x} - g)k(s-g) \text{ if } \tilde{x} \leq s \\ E\Pi(s,\tilde{x}) + Y - \int_g^s \delta(x-g)dx - \int_s^1 (x - s + \delta(s-g))dx - (1-g)k(s-g) \text{ otherwise.} \end{cases} \quad (11)$$

Rewriting the above equation with the help of (9) yields,

$$TS(s,\tilde{x}) = \begin{cases} Y - \int_g^{\tilde{x}} \delta(x-g)dx - \int_{\tilde{x}}^s \alpha\delta x dx - \int_s^1 (x - s + \alpha\delta s)dx - (1-g)k(s-g) \text{ if } \tilde{x} \leq s \\ Y - \int_g^s \delta(x-g)dx \; - \int_s^1 (x - s + \delta(s-g))dx - (1-g)k(s-g) \text{ otherwise.} \end{cases} \quad (12)$$

To close the model we assume that the regulator can commit to his strategy before the physicians take their decisions. This allows us to avoid problems of time inconsistency.

3 Optimal Regulation

In this section we will develop the analysis of the most efficient regulation under some alternative regulatory possibilities. This way, we will be able to spot the most important effects that are present in this market. In subsection 3.1, we will present the extreme situations, namely the completely decentralized and the first best scenarios. In subsection 3.2, we will study the most plausible situation, the partially decentralized scenario, in which the regulator controls the specialization choice, but not the private demand the specialists serve. We will analyze it first without considering cost subsidies, and afterwards introducing that dimension.

3.1 Complete Decentralized and First Best Scenarios

We will first study the complete decentralized scenario. In this case, the physicians control both variables, the level of specialization (s) and the demand (characterized by the indifferent agent $\tilde{x}$); the regulator becomes passive.

Proposition 1 *Under total decentralization, the resulting allocation is:*

$$s^{Td} = \tilde{x}^{Td} = \frac{(\delta - k)g + \delta(1-\alpha) - k}{2\left[\delta(1-\alpha) - k\right]}$$

$\forall k \in [0, \bar{k})$, *with* $\bar{k} = \frac{(1-\alpha-g)}{(1-g)}\delta$.

Notice that, due to the healing technology they are endowed with, the specialists' demand will always start at a degree of illness that they can completely heal ($\tilde{x} \leq s$). The individual with the lowest severity they treat is the one that defines the wage (we do not allow for price discrimination), and this patient is not willing to pay more for a more qualified specialist as long as the physician is enough specialized to fully heal her. Therefore, the physicians will not have incentives to specialize themselves more since this will not have repercussions into the wage they can charge to the intramarginal patients. As a result of this feature we get that $\tilde{x}^{Td} = s^{Td}$.

The upper bound $\bar{k}$ is the maximum value of the costs for which we have interior solutions, all through the paper we will restrict ourselves to the domain $k \in [0, \bar{k})$. This bound is decreasing in α, because the uncertainty is a source of inefficiency for the private provision, as it introduces a risk on their performance.

The other extreme scenario is the First Best situation, in which the physicians are passive and the regulator maximizes social welfare, disregarding the participation constraint of the physicians. This situation is unreal but we compute it because it represents the ideal situation the regulator should aim to.

Proposition 2 *The First Best allocation is:*

$$\begin{aligned}\tilde{x}^{1b} &= \frac{g}{1-\alpha}\\ s^{1b} &= 1-\frac{(1-g)k}{1-\alpha\delta}.\end{aligned}$$

The first consideration that arises from this proposition is the effect of the uncertainty on the market share. The uncertainty is a source of inefficiency for the private medical care hence its optimal demand is decreasing in α. Moreover, $\tilde{x}^{1b} > g$ for all $\alpha > 0$. This tells us the important role played in our model by the general practitioners, their screening behavior is what makes optimal (for every positive level of uncertainty) the coexistence of both systems of provision. This result provides a rationality for the "Gatekeeping" position of the GP's, based only on efficiency considerations. The fact that these physicians have a more versatile qualification than the specialists, gives them an additional ability to eliminate the uncertainty of the patients.

As one could expect, we find that in the total decentralization scenario the physicians serve a suboptimal fraction of the population, i.e. $\tilde{x}^{1b} < \tilde{x}^{Td}$.

There is an interesting insight concerning s^{1b}. The regulator, although the marginal cost of the specialization is constant (k), is not interested in forming "perfect physicians" even in the absence of uncertainty ($\alpha = 0$). On the one hand, contrary to other quality-concerned goods, medical care presents the interesting feature that, raising the quality does not benefit all the patients. The patients have a utility improvement from an increase in the quality of the physicians only if, in the previous situation, they suffered from underprovision (in our model this is the case when the physician's specialization was not enough to heal the disease). But, if they were fully treated (the provision of quality was enough for them), then a higher level of specialization has no effect on their utility. On the other hand, raising quality increases the costs of forming every specialist, as there is a homogenized specialization for all the physicians, except the general practitioners.

Corollary 1 *The physicians' specialization in the first best scenario is decreasing in α, while it is increasing under total decentralization.*

The intuition behind corollary 1 is clear: as we said before, the presence of uncertainty is a source of inefficiency for the specialized medical care, hence it is reasonable that for a given cost of specialization, the optimal level of qualification decreases as the degree of uncertainty increases. However, when the physicians are in control, they perceive this inefficiency differently. More uncertainty implies less power to attract patients to the

At this point, the reader may consider whether these inefficiencies we have found in the totally decentralized scenario are due to the assumption of monopoly power. The answer is no. If we consider that there is perfect competition in the market for specialists, we obtain very similar results. On the one hand, under perfect competition the quality choice of the physicians is inefficient and cannot be unambiguously ranked with respect to the optimal one. On the other hand, the quantity distortion is still present, although alleviated by the inability to extract profits. As the results do not seem to crucially depend on this assumption, and we consider that the monopoly structure fits better with the market we want to analyze, we will proceed with our analysis under the assumption that the specialists behave integrated as a monopoly.

3.2 Partially Decentralized Scenario

This subsection is devoted to the study of the situation in which the regulator can control the level of specialization, and the specialists retain the control over the price they charge, that is, the private demand they serve. We think this case is the most plausible scenario, the one that fits better with the actual situation of the market for specialized medical care in the mixed systems. We first study the case without cost subsidies, and afterwards we allow for its use.

Proposition 3 *Under partial decentralization without cost subsidies, the optimal level of specialization (s^{Pd}), and of private demand for the specialists ($\tilde{x}^{Pd}$) are:*

$$\tilde{x}^{1b} < \tilde{x}^{Pd} \leq s^{Pd} < s^{1b}.$$

With $\tilde{x}^{Pd} < s^{pd}$ for sufficiently low values of k.

The specialists, in this scenario, control the demand they serve, and choose to treat a suboptimal fraction of the population to be able to charge a high wage. Moreover, this restriction is more important as the level of specialization imposed by the regulator increases.

This link between quantity and quality distorts the optimal value of s. Even if the regulator controls the amount of specialization, he faces a trade-off: to impose a high standard of quality is costly because it induces a low level of private demand. This leads to the result $s^{Pd} < s^{1b}$. The physicians' reaction is triggered by the specialization cost k hence, unless the value of k is sufficiently low, the constraint $\tilde{x} \leq s$ will be binding.

Now we will introduce a new variable to the problem, the subsidies to specialization. We will consider a partially decentralized framework, as the previous one, in which we allow the regulator to decide what part of the costs of specialization will be publicly financed. Notice that this scenario is the one that more closely replicates the actual situation of the specialized medical care in Europe. The existing systems include a centralized selection of the level of specialization and subsidies to undertake this process of training.

Let us denote by $\beta \in [0, 1]$ the fraction of the costs of specialization financed with public expenditures. The regulation in this scenario leads to the following proposition:

Proposition 4 *Under partial decentralization with cost subsidies, the equilibrium is:*

a) If $\delta \leq \frac{1}{2}$ *and if* $\delta > \frac{1}{2}, \forall k \leq \bar{k}(\alpha, \delta, g)$, *then:*

$$\tilde{x}^{Pd} > \tilde{x}^{1b}, \; s^{Pd} = s^{1b}, \; \beta^{Pd} = 1.$$

b) Otherwise:

$$\tilde{x}^{1b} < \tilde{x}^{Pd} = s^{Pd} < s^{1b}, \; \beta^{Pd} \textit{ is undetermined,}$$

with $\frac{\partial k_{\max}(\alpha,\delta,g)}{\partial \alpha} < 0$, $\frac{\partial k_{\max}(\alpha,\delta,g)}{\partial \delta} < 0$, $\frac{\partial k_{\max}(\alpha,\delta,g)}{\partial g} < 0$.

The decision to subsidize the qualification of the physicians has important regulatory effects. The regulator wants highly qualified specialists and a large private supply of health care. Establishing subsidies to specialization makes (under certain conditions) both objectives attainable, by breaking the nexus that, in the other scenarios, linked high level of specialization with small private demand. This nexus was the specialization cost.

The regulator, by subsidizing the specialization intervenes in the market in a more effective way. In the previous scenario, the public sector was implicitly paying the specialization costs by ensuring the physicians that their revenues were enough to cover them, i.e. that their participation constraint was fulfilled . But with this, the regulator was not affecting the root of the problem because the specialists still perceived those costs, and therefore their incentives to charge them to the patients were not altered.

On the contrary, with the subsidization, the public sector expends resources, but directly affects the behavior of the specialists by removing the costs from their optimization program, resulting in a more efficient final allocation.

Notice that the level of specialization obtained when the regulation is possible is in fact, the first best level of specialization. Therefore: the use of subsidies to specialization serves to fully resolve the problem of the level of qualification of the specialized physicians. Recall that as it is pointed out in Corollary 2, under total decentralization the physicians can choose to overspecialize. This makes that, depending on the exact configuration of the parameters, the optimal regulation found here, can be the enforcement of a "quality ceiling", instead of a "minimum quality standard".

Corollary 3 *The level of private demand served under partial decentralization with cost subsidies (when the use of subsidies is possible) exceeds that of total decentralization.*

The importance of corollary 3 is that it shows how by using cost subsidies we improve over total decentralization also on the quantity dimension. Even though in this scenario the choice of demand is still decentralized, the presence of subsidies reduces the pressure of the physicians over the quantity. Now they are willing to treat more patients, as this will not raise their costs.

The use of the subsidies in the improvement of the regulation although it is restricted by the value of the parameters is of wide applicability. Numerical calculations show that, in fact, the range of values for which its use is not possible only has a relevant size for very high levels of uncertainty or of specialization costs (k).

Moreover, this cost reimbursement regulation is always feasible for values of $\delta \leq \frac{1}{2}$ and, beyond this threshold, its use possibilities are decreasing in δ. This brings to place the reference made in Section 2 about the non-urgent nature of the diseases we are considering. There, we said that the type of model we constructed, is only reasonable for non-urgent illnesses, and that, therefore, the value of δ should be constrained to be not very high. Hence, both, the range of parameters for which this modelization is natural and the range for which regulation is possible, seem to be determined by the same condition.

Finally, we would like to say that the results obtained with this model serve to understand the existing situation in the market for specialized medical care. In the countries with mixed systems, the process of centralized selection of the amount of specialization combined with the subsidization of the corresponding costs, can be supported as the outcome of an optimal process of regulation.

4 Conclusion

In this paper we have constructed a model to study the specialized medical care in an economy where public and private providers coexist. We took as a basis the Spanish case, where the formation of specialized physicians is completely regulated by means of a program called MIR (Internal Resident Physician), and where the specialists have the characteristic of being dual suppliers since they work for the public and the private system. Also this type of situation is present in other European countries like Italy.

Although the specialized medical care is one of the most important aspects of the provision of medical services, all the research undertaken in this field seemed to consider the qualification of the physicians as a given characteristic, and focused on the effect of different pricing policies on the market interaction. Thus, the qualification of the physicians was completely unattended by the literature. This article is an attempt to study the acquisition of the physicians' specialization. Moreover, we have been able to closely replicate the existing situation in the mixed health systems, with an analytically tractable model.

Our first contribution is to provide a new explanation for the "Gatekeeping" position of the General Practitioners based on their wider range of specialization. This versatility allows them to identify and treat several types of diseases, and therefore decreases the uncertainty present in the system.

We also spot the possible presence of overspecialization, when the physicians have control over the private demand they serve and also over their level of specialization. Even if they have to pay for their qualification, and the specialists do not internalize the positive effects of an increase of the specialization on those patients who previously were undertreated, the physicians' reaction to the presence of uncertainty in the market is to offer highly qualified services to a small fraction of the population.

The most interesting scenario is the one in which the physicians have control over the private demand they serve, but the regulator controls the amount of specialization. This case is specially important because it replicates the situation in the mixed systems of provision of health care. Our findings support the spirit of the actual policies as optimal, even though a more specific study would be necessary for each field. These mixed systems are based on a centralized choice of the level of specialization, combined with an almost complete subsidization of the associated costs; this is proven to be the best possible intervention, for the main range of parameter values, that coincides with the most reasonable one in terms of interpretation of the model.

We have chosen to develop our model under an specific kind of incomplete information. In our setting the uncertainty affects the patients' ability to recognize the type of illness they suffer. With this construction, we have been able to give an interpretation to the position of the general practitioners in the market. Their wider range of coverage (they are able to treat patients from any type of disease), makes them become providers of information, not only worse physicians. Notice that, a patient facing a high uncertainty has incentives to go to the general practitioner and avoid the costs associated with a visit to the wrong specialist.

The model we have developed has undoubtedly some shortcomings: the linear structure we have used for the disease and the costs of specialization is very simple. Nevertheless, it allowed us to obtain explicit solutions and provided us with good insights about the behavior of the agents. Moreover, we think that a more sophisticated construction would not qualitatively alter the main effects arising in our model.

The uncertainty that is present here is not the only possible type of uncertainty we can introduce. Also, the patient may not be able to observe the severity of the disease she has. This kind of incomplete information appears in the models that study the optimal role for the general practitioners from the perspective of agency theory. These models confront two situations: one, in which the visit to the general practitioner is voluntary, and another, where it is compulsory, (a good example of this literature is García-Mariñoso and Jelovac [12]).

Finally, the MIR program we have taken as the basis of our study is, among other things, a quantity setting device. The amount of physicians that will receive specialized training in each field is fixed in advance to the selection or matching process, that is based on a tournament. The number of positions offered in each speciality should be chosen, then, taking into account the presumed evolution of the demand, and some supply side considerations like the retirement of active specialists. This is also an interesting issue that we did not address. Therefore, a natural extension of this article is to introduce the amount of free positions as a choice variable, taking into account the possible coordination failures between the population of potential specialists and the regulator, in the selection of the field of specialization.

5 Appendix

Proof of Lemma 1:

Due to the equal probability of both illnesses, in expected terms, and for every degree of severity, half of the population who is ill, will suffer from each type of disease. To characterize the demand, we look for the indifferent patient, $\tilde{x}$. To do it we use the fact that $EU_{pri}(\cdot) - EU_{pub}(\cdot)$ is non-decreasing in x, and strictly decreasing for $x \leq s$. We have to study two possible regions. For $\tilde{x} \in (g, s]$ the equality of the expected utilities implies:

$$EU_{pub}(x, g, s, \delta, \alpha) = EU_{pri}(x, g, s, \delta, \alpha, w) \Longrightarrow \tilde{x} = \frac{g}{1-\alpha} + \frac{w}{\delta(1-\alpha)}.$$

This condition defines the degree of severity from which on the patients will prefer to go to a private medical supplier, since:

$\forall x > \tilde{x}, EU_{pri}(x, g, s, \delta, \alpha, w) > EU_{pub}(x, g, s, \delta, \alpha)$.

To ensure that this is sufficient to characterize the patients' behavior we need to consider what happens in the region $x \in (s, 1]$. The equality of the utilities implies

$$EU_{pub}(x, g, s, \delta, \alpha) = EU_{pri}(x, g, s, \delta, \alpha, w) \Longrightarrow \tilde{x} = s.$$

If for $x = s$, $EU_{pub}(x, g, s, \delta, \alpha) > EU_{pri}(x, g, s, \delta, \alpha, w)$, then:

$\forall x \geq s, EU_{pub}(x, g, s, \delta, \alpha) > EU_{pri}(x, g, s, \delta, \alpha, w)$. Recall that for $x > s$ both functions are parallel. Therefore the indifferent patient will never be in this region.

■

Proof of Proposition 1:

In order to solve optimally we need to consider the physicians' decisions. They will maximize (9). The profit function is defined in two segments: if $\tilde{x} \leq s$, that is if there exists private supply of specialized care, and if there is only public specialized care. The physicians will always be interested in the existence of private provision, provided they make positive private profits. Hence, they will search their optimum in the region defined by $\tilde{x} \leq s$, taking into account the Participation Constraint given by (10)

Then, their objective function is:

$$\max_{s,\tilde{x}} \Pi(s,\tilde{x}) = \max_{\tilde{x},s} \Pi_{pub} + (1-\tilde{x})[\delta((1-\alpha)\tilde{x} - g) - k(s-g)]$$
$$s.t \quad \begin{cases} \tilde{x} \leq s \\ \tilde{x} \geq \frac{g}{1-\alpha} + \frac{k(s-g)}{\delta(1-\alpha)} \qquad \text{(PC).} \end{cases} .$$

The first order conditions associated with the unconstrained problem are:

$\frac{\partial \Pi(s,\tilde{x})}{\partial s} = -k(1-\tilde{x}) < 0 \ \forall s. \Longrightarrow$ The constraint

Performing the first order conditions in the above program yields:

$\frac{\partial TS(s,\tilde{x})}{\partial \tilde{x}} = 0 \Rightarrow \tilde{x}^* = \frac{g}{1-\alpha}$.

$\frac{\partial TS(s,\tilde{x})}{\partial s} = 0 \Longrightarrow s^* = 1 - \frac{k(1-g)}{1-\alpha\delta}$.

The second order conditions are fulfilled.

These will be the solution if they fulfill $\tilde{x}^* \leq s^*$. Computations show that $\forall k \in (0, \bar{k})$, $\tilde{x}^* \leq s^*$. Hence:

$$\begin{aligned} \tilde{x}^{1b} &= \frac{g}{1-\alpha} \\ s^{1b} &= 1 - \frac{k(1-g)}{1-\alpha\delta}. \end{aligned}$$

■

Proof of Corollary 1:

By computing the derivatives we get:

$\frac{\partial s^{1b}}{\partial \alpha} < 0$.

$\frac{\partial s^{Td}}{\partial \alpha} > 0$.

■

Proof of Corollary 2:

$s^{1b} > s^{Td} \Longleftrightarrow (1-g)\left[(1-\alpha\delta)(\delta-k) - 2k(\delta(1-\alpha)-k)\right] - (1-\alpha\delta)\delta\alpha > 0$.

If $\alpha = 0$, then $s^{1b} > s^{Td}$, $\forall(\delta, g, k)$.

However, for strictly positive values of α, the sign of the above condition is not attainable explicitly. Numerical computations show that for $\alpha > 0$ the relation between s^{1b} and s^{Td} is ambiguous.

■

Proof of Proposition 3:

We solve by backwards induction, hence we start by the last stage: physicians' decision. They will maximize (9). The specialists will choose to serve private demand, that is $\tilde{x} \leq s$. Then, their objective function is:

$$\begin{aligned} \max_{\tilde{x}} \Pi(s,\tilde{x}) &= \max_{\tilde{x}} \Pi_{pub} + (1-\tilde{x})[\delta((1-\alpha)\tilde{x} - g) - k(s-g). \\ & s.t \quad \begin{cases} \tilde{x} \leq s \\ \tilde{x} \geq \frac{g}{1-\alpha} + \frac{k(s-g)}{\delta(1-\alpha)} \qquad \text{(PC)}. \end{cases} \end{aligned}$$

The first order condition of the unconstrained problem yields,

$\frac{\partial \Pi(\tilde{x})}{\partial \tilde{x}} = 0 \Longrightarrow \tilde{x}(s) = \frac{1-\alpha+g}{2(1-\alpha)} + \frac{k(s-g)}{2\delta(1-\alpha)}$. This interior point will be the solution only if $\tilde{x}(s) \leq s$, i.e. if $s \geq \frac{(1-\alpha)\delta+g(\delta-k)}{2\delta(1-\alpha)-k}$, when the solution is interior the Participation Constraint is fulfilled.

If not then $\tilde{x}(s) = s$, this will be their choice provided (PC) is satisfied, which is the case only if $s \geq \frac{g(\delta-k)}{\delta(1-\alpha)-k}$. Hence, the physicians' demand is:

$$\tilde{x}(s) = \begin{cases} \frac{1-\alpha+g}{2(1-\alpha)} + \frac{k(s-g)}{2\delta(1-\alpha)} & \text{if } s \geq \frac{(1-\alpha)\delta+g(\delta-k)}{2\delta(1-\alpha)-k} \\ s & \text{if } s \in \left[\frac{g(\delta-k)}{\delta(1-\alpha)-k}, \frac{(1-\alpha)\delta+g(\delta-k)}{2\delta(1-\alpha)-k}\right) \\ 1 & \text{otherwise.} \end{cases}$$

In the previous stage the regulator will maximize (12). The program he solves is:

$$\begin{aligned} \max_s TS(s, \tilde{x}(s)) = \max_s Y &- \int_g^{\tilde{x}(s)} \delta(x-g)dx - \int_{\tilde{x}(s)}^s \alpha\delta x dx - \int_s^1 (x - s + \alpha\delta s)dx \\ &- (1-g)k(s-g) \\ &s.t. \quad \tilde{x} \leq s \end{aligned}$$

As the physicians' choice can take different values we have to study independently all the cases. Assuming first we are in the region with interior solution for $\tilde{x}(s)$, the regulator's objective function is

$$\begin{aligned} \max_s TS(s) = \max_s Y &- \int_g^{\frac{1-\alpha+g}{2(1-\alpha)} + \frac{k(s-g)}{2\delta(1-\alpha)}} \delta(x-g)dx - \int_{\frac{1-\alpha+g}{2(1-\alpha)} + \frac{k(s-g)}{2\delta(1-\alpha)}}^s \alpha\delta x dx - \int_s^1 (x - s + \alpha\delta s)dx \\ &- (1-g)k(s-g) \\ &s.t. \quad \tilde{x} \leq s \end{aligned}$$

The first order condition is:

$\frac{\partial TS(s)}{\partial s} = \frac{-k}{2}\left[\tilde{x}(s) - \frac{g}{1-\alpha}\right] + (1-\alpha\delta)(1-s) - (1-g)k = 0$. From here we can find an implicit relation of the value of s with respect to s^{1b}.

$\frac{\partial TS(s)}{\partial s} = 0 \Longrightarrow s^* = s^{1b} - \frac{k}{2(1-\alpha\delta)}\left[\tilde{x}(s) - \frac{g}{1-\alpha}\right] < s^{1b}$.

This will only be the solution if it fulfills the consistency constraint $s^* \geq \tilde{x}(s^*)$. That is, if $s^* \geq \frac{(1-\alpha)\delta+g(\delta-k)}{2\delta(1-\alpha)-k}$ Algebraic manipulations are not sufficient to show when does this occur, therefore we need to perform numerical approximations. The result of these computations is that only if k is low enough (the upper bound of k moves between 0.05 and 0.2 for different values of α and δ). Thus, when the condition is not verified we need to study the region in which $\tilde{x} = s$. The regulator's program is:

$$\max_s TS(s) = \max_s Y - \int_g^s \delta(x-g)dx - \int_s^1 (x - s + \alpha\delta s)dx - (1-g)k(s-g).$$

The optimization decision with respect to s is:
$\frac{\partial TS(s)}{\partial s} = 0 \Longrightarrow s^* = \frac{1-\alpha\delta+\delta g-(1-g)k}{1+\delta(1-2\alpha)}$.
From the $\frac{\partial TS(s)}{\partial s}$ it is straightforward to see that $s^* < s^{1b}$.

This is the candidate for maximum, with $\tilde{x}^* = s^*$. However this will only be the solution if it fulfills the Participation Constraint of the physicians, given by the lower bound for s, $s \geq \frac{g(\delta-k)}{\delta(1-\alpha)-k}$. Therefore the solution in this region is: $\tilde{x}^{Pd} = s^{Pd} = \max\left\{\frac{1-\alpha\delta+\delta g-(1-g)k}{1+\delta(1-2\alpha)}, \frac{g(\delta-k)}{\delta(1-\alpha)-k}\right\}$.

Summarizing:

$$\tilde{x}^{1b} < \tilde{x}^{Pd} \leq s^{Pd} < s^{1b}.$$

The second order conditions are fulfilled.

This completes the proof.

■

Proof of Proposition 4:

We solve by backwards induction, hence we start by the last stage: physicians' decision. They will maximize (9). The specialists will choose to serve private demand, that is $\tilde{x} \leq s$. Then, their objective function is:

$$\begin{aligned} \max_{\tilde{x}} \Pi(s,\tilde{x}) &= \max_{\tilde{x}} \Pi_{pub} + (1-\tilde{x})[\delta((1-\alpha)\tilde{x} - g) - (1-\beta)k(s-g)] \\ & s.t \quad \begin{cases} \tilde{x} \leq s \\ \tilde{x} \geq \frac{g}{1-\alpha} + \frac{(1-\beta)k(s-g)}{\delta(1-\alpha)} \qquad \text{(PC)}. \end{cases} \end{aligned}$$

Proceeding analogously as in the proof of proposition 3 we characterize the physicians' behavior:

$$\tilde{x}(s,\beta) = \begin{cases} \frac{1-\alpha+g}{2(1-\alpha)} + \frac{(1-\beta)k(s-g)}{2\delta(1-\alpha)} & \text{if } s \geq \frac{(1-\alpha)\delta+g(\delta-(1-\beta)k)}{2\delta(1-\alpha)-(1-\beta)k} \\ s & \text{if } s \in \left[\frac{g(\delta-(1-\beta)k)}{\delta(1-\alpha)-(1-\beta)k}, \frac{(1-\alpha)\delta+g(\delta-(1-\beta)k)}{2\delta(1-\alpha)-(1-\beta)k}\right) \\ 1 & \text{otherwise.} \end{cases}$$

In the previous stage the regulator will maximize (12). The program he solves is:

$$\begin{aligned} \max_{s,\beta} TS(s,\tilde{x}(s,\beta)) = \max_{s,\beta} Y &- \int_g^{\tilde{x}(s,\beta)} \delta(x-g)dx - \int_{\tilde{x}(s,\beta)}^s \alpha\delta x dx - \int_s^1 (x-s+\alpha\delta s)dx \\ &- (1-g)k(s-g) \\ &s.t. \quad \tilde{x} \leq s \end{aligned}$$

As the physicians' choice can take different values we have to study independently all the cases. Assuming first we are in the region with interior solution for $\tilde{x}(s,\beta)$, the regulator's objective function is

$$\begin{aligned} \max_{s,\beta} TS(s,\beta) = \max_{s,\beta} Y &- \int_g^{\frac{1-\alpha+g}{2(1-\alpha)}+\frac{(1-\beta)k(s-g)}{2\delta(1-\alpha)}} \delta(x-g)dx - \int_{\frac{1-\alpha+g}{2(1-\alpha)}+\frac{(1-\beta)k(s-g)}{2\delta(1-\alpha)}}^s \alpha\delta x dx \\ &- \int_s^1 (x-s+\alpha\delta s)dx - (1-g)k(s-g) \\ &s.t. \quad \tilde{x} \leq s \end{aligned}$$

The first order condition with respect to β is:

$\frac{\partial TS(s,\beta)}{\partial\beta} = \frac{k(s-g)}{2}\left(\frac{1-\alpha-g}{2(1-\alpha)} + \frac{(1-\beta)k(s-g)}{2\delta(1-\alpha)}\right) > 0, \forall\beta \in [0,1]. \Longrightarrow$ The solution is boundary for β therefore $\beta^* = 1$. Introducing this value in the program and computing the first order condition for s gives:

$\frac{\partial TS(s,\beta=1)}{\partial s} = (1-s)(1-\delta\alpha) - (1-g)k = 0 \Longrightarrow s^* = 1 - \frac{(1-g)k}{1-\alpha\delta} = s^{1b}$.

The second order conditions are fulfilled.

This will only be the solution if it fulfills that $s^* \geq \frac{1-\alpha+g}{2(1-\alpha)}$. The inequality can be rewritten as the following condition (C1):

$$(1-\alpha\delta)(1-\alpha-g) - 2k(1-\alpha)(1-g) > 0.$$

C1 can be rewritten in terms of the maximum k for which the condition is fulfilled: $k \leq \frac{(1-\alpha\delta)(1-\alpha-g)}{2(1-\alpha)(1-g)} = k_{\max}(\alpha,\delta,g)$. It is easy to check that: $\frac{\partial k_{\max}(\alpha,\delta,g)}{\partial\alpha} < 0$, $\frac{\partial k_{\max}(\alpha,\delta,g)}{\partial\delta} < 0$, $\frac{\partial k_{\max}(\alpha,\delta,g)}{\partial g} < 0$.

We find that $\forall\delta \leq \frac{1}{2}$, $k_{\max}(\alpha,\delta,g) \geq \bar{k}$. Therefore for these values of δ, C1 is always fulfilled. For values of $\delta > \frac{1}{2}$, we need to perform numerical approximations. With them we find that the range of values of k, for which C1 does not hold is only relevant for high levels of δ or α.

Hence when the condition is fulfilled:

$$\tilde{x}^{Pd} = \frac{1-\alpha+g}{2(1-\alpha)} > \tilde{x}^{1b}$$
$$s^{Pd} = 1 - \frac{(1-g)k}{1-\alpha\delta} = s^{1b}$$
$$\beta^{Pd} = 1.$$

When C1 is not fulfilled, we have to search for the equilibrium in the region $\tilde{x} = s$. The rest of the proof replicates the second case in the proof of the previous proposition. In this case, the value of β is undefined as it is a transfer that does not appear in the objective function.

■

Proof of Corollary 3:

Simple algebraic manipulations show that $\tilde{x}^{Pd} < \tilde{x}^{Td}$, when the use of cost subsidies is possible.

■

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