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The pricing of physicians' services with distant medicine and health insurance

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Abstract:

Telemedicine is often put forward as a solution to medical deserts. Recently, telemedicine has allowed to limit physical contacts during a pandemic. We analyze within a theoretical model the setting of physicians' fees in the presence of distant medicine and public health insurance, as well as the resulting patients' surplus, access and public expenses. Concretely, we consider that distant medicine is provided either by the same physician as in-person medicine or by another one specialized in distant medicine. We compare the outcomes of these two market structures with each other and with a benchmark monopoly with no distant medicine. This comparison allows to discuss the effects of a recent French reform concerning insurance reimbursements for distant medicine, as well as those of cross-border high-quality remote health services.

Keywords:

Distant medicine; pricing; insurance; medical deserts

JEL codes:

I11; I13; L13

Working
Paper

The pricing of physicians' services with distant medicine and health insurance*

EMILIE DARGAUD[†] AND IZABELA JELOVAC[‡]

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ABSTRACT. Telemedicine is often put forward as a solution to medical deserts. Recently, telemedicine has allowed to limit physical contacts during a pandemic. We analyze within a theoretical model the setting of physicians' fees in the presence of distant medicine and public health insurance, as well as the resulting patients' surplus, access and public expenses. Concretely, we consider that distant medicine is provided either by the same physician as in-person medicine or by another one specialized in distant medicine. We compare the outcomes of these two market structures with each other and with a benchmark monopoly with no distant medicine. This comparison allows to discuss the effects of a recent French reform concerning insurance reimbursements for distant medicine, as well as those of cross-border high-quality remote health services.

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1. INTRODUCTION

Medical deserts and balance billing are problematic cornerstones in the French health care system. Indeed, demographic dynamics has led some regions in France to be underprovided in terms of physicians' presence and services. In turn, balance billing, i.e. the possibility for physicians to set their own fees, can be problematic when high physicians' fees restrict the access to health care even more. The recent pandemic has added new challenges to the system. Physicians, and health care workers in general, have been central in the alleviation of the sanitary crisis, at the risk of being infected and spreading the pandemic even further.

Telemedicine has been put forward as a way to alleviate the issue of medical deserts. It has also proved very useful to facilitate the provision of physicians' services while

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restricting unnecessary and dangerous physical contacts during pandemics. However, in a system that allows balance billing, it is important not only to anticipate the pricing of telemedicine, but also how this pricing strategically interacts with the pricing of face-to-face medicine and, ultimately, the consequences on patients' welfare and public expenses.

To reflect the physicians' ability to set their own fees in a system with balance billing, we analyze how telemedicine influences physicians' pricing decisions both in a monopolistic setting and in a competitive one. To account for the widespread social protection of patients in France and in many developed countries, we also consider differentiated reimbursement rates for face-to-face medicine and for distant medicine and we analyze their effect on pricing. The analysis of pricing allows us to derive conclusions both about access to medicine and about public expenses. Ultimately, our setting allows us to answer the following questions: Should each physician supply both face-to-face and distant medicine or should physicians specialize in either type of medicine? This question is important to qualify the pros and cons of different regulations regarding telemedicine. For instance, the French law forbids physicians and firms to exclusively provide telemedicine while firms that specialize in distant medicine are widespread in the US. Moreover, our modeling is flexible enough to appreciate a recent reform in France, which has decreased the insurance reimbursement for remote medicine so as to equalize it with the one for in-person medicine.

The present paper relates to three strands of the literature. Up to our knowledge, it is the first one to link these three interdependent series of issues.

First, the literature on spatial price competition provides useful and flexible models to represent the market for health services, among others (Colombo ed., 2020). Medical fees are regulated in numerous health care systems so that health economics often focus on quality competition rather than on fees (Brekke et al., 2011, among others). Since we focus on a system with balance billing, we prefer to directly model fees interaction between face-to-face and distant medicine.

Second, the present paper relates to the strand of health economics that analyzes the role of health insurance. For example, Jelovac (2015b) shows that supplemental insurance against the expenses associated with balance billing, rather than alleviating the access problem, increases it. This result holds in a monopoly setting with no distant medicine.

To account for distant medicine, we highly relate to a third strand of the literature that theoretically analyzes the impact of online competitor(s) on brick-and-mortar "firm(s)". Pioneered work by Balasubramanian (1998) and complemented in a multistage game by Bouckaert (2000) uses a setting involving a circular spatial market as in Salop's model (1979). Afterwards, Nakayama (2009) examines in a linear city model (Hotelling's model, 1929) the situation where some consumers ("old") are constrained to purchase only from conventional retailers while others ("young") have access to the Internet. Colombo and Matsushima (2020) contributes to this literature investigating heterogeneous consumers with respect to the costs of traveling to either of the offline retailers but also to the costs of purchasing from the online retailer. Other several studies endogeneize the choice of location (Foncel et al. (2011), Guo and Lai (2017), Dargaud and Jouneau-Sion (2020) or Colombo and Hou (2021)). Our work is closely related to this literature but the main difference is that we deal with the consumer surplus implications focusing on which provider delivers the online service (the same physician as face-to-face medicine or an independent one). Dargaud and Jouneau-Sion (2020) proposes a model in which the online product ("MOOC") can be offered by the traditional firm (brick and mortar university) but a crucial difference is that they set the price of the online product to

zero and assume a fixed disutility of the MOOC, and focus on either localization choice or/and competition between traditional suppliers facing an on-line course. In our paper we endogenize the price of each health service: face-to-face but also distant medicine. We also examine the role of another key variable: the patient's co-payment.

Our analysis amounts to compare a dual monopoly and a specialized duopoly, using a Hotelling model that is specific to balance billing, health insurance and the existence of both face-to-face and distant medicine. The salient results of this paper are the following. We first show that remote medicine improves access when there are medical deserts, no matter whether it is provided by the same physician as in-person medicine or not. Second, we show that a joint provision of remote and face-to-face services by the same physician results in a peculiar form of price discrimination, where discrimination is based on location, as in Greenhut and Greenhut (1975) and in Thisse and Vives (1988). Because the location of remote patients does not matter, the monopoly physician in our setting is able to price them at their maximum willingness-to-pay so as to entirely extract their surplus. Such a price discrimination leads to a decrease of the consumer surplus, as compared to a situation without remote medicine, despite of solving the medical desert issue. Instead, when in-person and distant medicine are provided by distinct physicians, the competition leads to the lowest fees and the highest consumer surplus, as compared to the other market structures. This one result is compatible with Nakayama (2009), which claims that e-commerce enhances retail competition and always increases consumer surplus. Third, the fees are generally higher where quality is higher, that is, with in-person medicine as compared to distant medicine. One exception appears in the case of a specialized duopoly: When transportation costs are high enough, so are the market power and the fee associated to distant medicine, despite of a lower quality. Here, only this exception is compatible with the result of Colombo and Hou (2021) that the price of an online retailer might be higher or lower than that of traditional retailers because the qualities need not be different in their model. Fourth, we show that under any market structure, the consumer surplus increases (decreases) in transportation costs when the latter are low (high) enough.

The comparison of both market structures in terms of public expenses is ambiguous and depends on relative co-payments, distances and transportation costs. Moreover, the effect of patients' co-payments can be non-trivial. We show for instance that in a monopoly offering both types of medicine, the consumer surplus is increasing in the co-payment for distant medicine and decreasing in its quality. We also show that in all cases but one, the effect of co-payments is typical of models with linear demands: The equilibrium fees adjust to co-payments in such a way that demands and consumer prices remain constant. We find however one exception in the case of a monopoly offering both types of medicine.

Finally, in an extension, we confirm our main results when we consider that the quality is highest online, as long as the quality differential is not too high. Instead, if it is too high, then face-to-face medicine may disappear in favor of distant high-quality medicine, even if the latter is not reimbursed. This result is in line with Bouckaert (2000), which concludes that fewer firms are active with free entry of distant (mail order) business. Last, we refer to a recent reform in France. Since the beginning of the Covid-19 pandemics until July 2022, there was no co-payment for telemedicine in France. After July 2022, the co-payment rate for telemedicine has increased to reach the same level as the one for in-person medicine (approximately 30%). Following our analysis, we predict a decrease in the fees for both types of medicine, a lower consumer surplus and lower public expenses.

The paper proceeds as follows. In Section 2 we describe the model. Sections 3 and 4 respectively describe the results obtained with a single physician or with a specialized duopoly. The various cases are compared in Section 5. Section 6 analyzed the effects of differentiated copayments. In Section 7 we discuss some extensions. Last Section 8 concludes. Proofs are in Appendix.

2. MODEL SETUP

In the spirit of a Hotelling model, we consider individual patients geographically distributed on a line: $x \sim U[0, L]$. Unitary transportation costs are denoted t . The value of a diagnosis is either d_c or d_e , according to whether it is face-to-face after a clinical examination or online after a questionnaire, with $d_c > d_e$.¹² The corresponding fees, denoted p_c and p_e , are endogenous. D_c or D_e designate the corresponding demands. Health insurance reimburses a fraction $1 - \alpha_i$ of the fees so that patients only pay a fraction α_i , with $i = c, e$. We do not impose the sign of $\alpha_c - \alpha_e$. We consider either one (A) or two physicians (A and B). When A provides face-to-face health services, she does so from the exogenous location $x = 0$. We assume no cost per patient for the health provider.

3. SINGLE PHYSICIAN

3.1. Single physician with no distant medicine

As a benchmark situation, we consider here that A is the unique physician in the area $[0, L]$ and she provides no distant medicine. An individual patient located at x decides whether to visit physician A or not and his utility is

$$U = \max\{d_c - \alpha_c p_c - tx; 0\}. \quad (3.1)$$

Therefore, the indifferent patient is located at

$$\tilde{x} = \min\{\max\{0; \frac{d_c - \alpha_c p_c}{t}\}; L\}. \quad (3.2)$$

We can thus write the physician's profit as

$$\Pi_A = p_c \tilde{x}. \quad (3.3)$$

The maximization of such a profit directly leads to the solution described in Lemma 1, where CS and PE denote consumer surplus and public expenses, respectively.³

LEMMA 1. (*Single clinician, solution*)

1. When $2tL \leq d_c$, then

¹The reason is that a physician can perform many aspects of a diagnosis in both distant and in-person settings except the clinical examination, which is possible in-person only. Misdiagnoses and medication mistakes are not rare in telemedicine, see for example Khoong *et al.* (2022) and Resneck *et al.* (2016).

²When discussing extensions in Section 7, we consider the alternative assumption $d_c < d_e$ to reflect some specific situations.

³Here, public expenses amount to the health insurance reimbursements: $PE = (1 - \alpha_c)p_c D_c + (1 - \alpha_e)p_e D_e$.

- $p_c = \frac{d_c - tL}{\alpha_c}$; $D_c = L$; $\Pi_A = \frac{d_c - tL}{\alpha_c} L$
- $CS = \frac{tL^2}{2}$; $PE = \frac{1 - \alpha_c}{\alpha_c} (d_c - tL)L$

2. When $d_c \leq 2tL$, then

- $p_c = \frac{d_c}{2\alpha_c}$; $D_c = \tilde{x} = \frac{d_c}{2t}$; $\Pi_A = \frac{(d_c)^2}{4\alpha_c t}$
- $CS = \frac{(d_c)^2}{8t}$; $PE = \frac{1 - \alpha_c}{\alpha_c} \frac{(d_c)^2}{4t}$

Therefore, when $d_c < 2tL$, part of the market is not covered, $D_c < L$, and we have a medical desert. Lemma 2 provides a verbal interpretation of some selected items of the solution, including comparative statics.

LEMMA 2. (*Single clinician, interpretation*)

If transportation costs and/or distance are large, then part of the market is not covered. The medical desert is independent on the patient's co-payment. Fee and profit are decreasing in patient's co-payment and they are both lowest when a medical desert exist. The consumer surplus is first increasing and then decreasing in transportation costs, t .

Central to this analysis is the possible existence of a medical desert. It is very intuitive that a medical desert exists when distance and transportation costs are high enough, as stated in Lemma 1. Co-payments have no influence on the occurrence of medical deserts because even if co-payments decrease fees, the part of the fee that is paid by patients does not depend on co-payments (see Section 6 for a general discussion about the effect of co-payments). When transportation costs and distance are so low that a medical desert does not exist, then the direct effect of an increase in transportation costs t is to increase patients' utility. For low t , it is worthwhile for the physician to lower its fee p to compensate for higher transportation costs t and keep the demand from all patients, even for those located furthest away, at L . The decrease in fee is therefore higher than the average increase in transportation costs. This explains why consumer surplus is increasing in t when there is no medical desert. Indeed, the direct effects of higher transportation costs on utility are more than compensated by a negative effect on the fee.

When instead, transportation costs and distance are high enough so that a medical desert appears, then an increase in transportation costs t is not worth a decrease in fee for the physician to maintain a high demand. Therefore, the fee now does not vary with transportation costs and total demand decreases in t . The resulting profit and consumer surplus are thus decreasing in transportation costs when the latter are high.

3.2. Single physician with both face-to-face and distant medicine

In this section, the physician A , located at $x = 0$, provides both face-to-face and distant medicine without any capacity constraint.

An individual patient located at x decides whether or not to visit physician A , either physically, incurring a traveling cost of tx , or virtually, incurring no traveling cost. His utility is therefore

$$U = \max\{d_c - \alpha_c p_c - tx; d_e - \alpha_e p_e; 0\} \quad (3.4)$$

Here, the patient indifferent between in-person and distant medicine is located at

$$\tilde{x}_2 = \min\{\max\{0; \frac{d_c - d_e + \alpha_e p_e - \alpha_c p_c}{t}\}; L\}. \quad (3.5)$$

The physician's profit is therefore

$$\Pi_A = p_c \tilde{x}_2 + p_e (L - \tilde{x}_2). \quad (3.6)$$

The solution that maximizes the single physician's profits is characterized in Lemma 3.⁴

LEMMA 3. (*Single physician, solution*)

1. When $2tL \leq d_c - \frac{\alpha_c}{\alpha_e} d_e$, then

- $p_c = \frac{d_c - tL}{\alpha_c}$; $D_c = L$
- $p_e = \frac{d_e}{\alpha_e}$; $D_e = 0$
- $\Pi_A = \frac{d_c - tL}{\alpha_c} L$
- $CS = \frac{t}{2} L^2$; $PE = \frac{1 - \alpha_e}{\alpha_c} (d_c - tL)L$

2. When $0 \leq d_c - \frac{\alpha_c}{\alpha_e} d_e \leq 2tL$, then

- $p_c = \frac{\alpha_e d_c + \alpha_c d_e}{2\alpha_c \alpha_e}$; $D_c = \frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e t}$
- $p_e = \frac{d_e}{\alpha_e}$; $D_e = L - \frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e t}$
- $\Pi_A = \frac{d_e}{\alpha_e} L + \frac{1}{\alpha_c t} \left(\frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e} \right)^2$
- $CS = \frac{1}{2t} \left(\frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e} \right)^2$; $PE = (1 - \alpha_c) \frac{\alpha_e d_c + \alpha_c d_e}{2\alpha_c \alpha_e} \frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e t} + (1 - \alpha_e) \frac{d_e}{\alpha_e} \left(L - \frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e t} \right)$

3. When $d_c - \frac{\alpha_c}{\alpha_e} d_e \leq 0$, then

- $p_c > \frac{d_c}{\alpha_c}$; $D_c = 0$
- $p_e = \frac{d_e}{\alpha_e}$; $D_e = L$
- $\Pi_A = \frac{d_e}{\alpha_e} L$
- $CS = 0$; $PE = \frac{1 - \alpha_e}{\alpha_e} d_e L$

Part 3 of Lemma 3 corresponds to a situation where distant medicine is so better reimbursed than face-to-face medicine that all patients choose distant visits despite the lower quality of diagnosis. For the other cases, fees are always higher for face-to-face visits than for distant ones. This is due to the quality of the diagnosis that is higher face-to-face. Furthermore, fees for distant visits are always set so as to fully extract surplus from patients. Indeed, the location of distant patients is not important anymore when they use remote medicine. Therefore, they all have the same utility and a physician can perfectly discriminate all of them (first-degree price discrimination).

LEMMA 4. (*Single physician, interpretation*)

There is no medical desert if the physician can use both face-to-face and distant medicine. The fee is higher for face-to-face visits as compared to distant medicine. The demand for face-to-face [distant] medicine decreases [increases] in $\frac{\alpha_c}{\alpha_e}$ and in the value of distant medicine, d_e , and it increases [decreases] in the value of face-to-face medicine,

⁴Proof in Appendix 9.1.

d_c . The single physician provides distant medicine only when α_e and d_c are low enough relative to α_c and d_e . Fees and profits increase with the value of medicine (d_c and d_e) and they decrease with co-payment rates. The consumer surplus increases in d_c and it decreases in both d_e and $\frac{\alpha_c}{\alpha_e}$. It increases or decreases in transport unit cost t . Public expenses decrease with co-payment rates and with d_e and they increase with d_c .

The difference between face-to-face and distant fees is due to the difference in diagnosis qualities. An interesting result is the impact of d_e and α_e . It is striking to observe that the consumer surplus is (weakly) increasing in α_e , the co-payment for distant medicine, while it is decreasing in d_e , the value of a distant diagnosis. The reason is that both an increase in α_e and a decrease in d_e make some patients switch from distant medicine to face-to-face medicine. Distant medicine is priced so as to extract the full surplus away from consumers ($p_e = \frac{d_e}{\alpha_e}$ leading to zero utility), while face-to-face medicine is priced so as to extract the surplus from the marginal consumer only. Then only face-to-face medicine provides positive surplus to patients. Therefore, an increase in α_e (or a decrease in d_c) increases individual surplus for all switchers but the marginal one. The corresponding fee (p_c) decreases in both copayments while the corresponding demand (D_c) decreases in α_c and increases in α_e , which corresponds to the effect on consumers' surplus. The effect of the transportation cost on the consumer surplus is similar to the one depicted and explained for the benchmark situation with no distant medicine.

Public expenses increase in the length of the geographical line. This is intuitive since the entire population is now served and demand therefore mechanically increases with the size of the population. We also observe that total expenses ($p_c D_c + p_e D_e$) decrease in transportation costs, t . The reason is that fees are higher for face-to-face visits because of the higher quality. Therefore, it is overall less expensive when people use distant medicine. Besides, demand for face-to-face medicine logically decreases with transport costs. Therefore, total expenses decrease in t . So do public expenses as long as copayment are not too unbalanced in favor of distant medicine, in which case fees and reimbursements for distant visits would adjust upward.

3.3. Comparison

There is no medical desert anymore when distant medicine is possible. We focus on the case where $d_c \geq \frac{\alpha_c}{\alpha_e} d_e$, with positive demand for face-to-face medicine. The fee for face-to-face visits, p_c , as well as provider's profits are higher when distant medicine is possible, which is intuitive since having two types of medicines allows the provider to discriminate between nearby and distant patients. Surprisingly, the consumer surplus decreases when distant medicine is possible, even when it overcomes the medical desert issue. Again, this is related to third-degree price discrimination together with a fee for distant visits that fully extracts the surplus away from consumers. Actually, the patients who are closest to the physician obtain a lower utility when distant medicine exists, because the fee for in-person medicine has increased due to price discrimination. The furthest patients who are in a medical desert when distant medicine does not exist keep the same utility with distant medicine since it is priced at their maximum willingness-to-pay. The patients in intermediate locations are those who switch from in-person to distant medicine when the latter is available, because of the relative fees in favor of distant medicine but still with a lower utility due to full surplus extraction. In total, patients either lose utility or keep the same one after the introduction of telemedicine.

4. DUOPOLY WITH SPECIALIZED PHYSICIANS

In this subsection, we consider that A , located at address $x = 0$, performs face-to-face medicine while B performs distant medicine from whatever location. Here, the utility of an individual patient located at x is

$$U = \max\{d_c - \alpha_c p_c - tx; d_e - \alpha_e p_e; 0\}. \quad (4.1)$$

We start considering that $d_e - \alpha_e p_e \geq 0$. The location of the indifferent consumer is the same as in the case of a single physician with both face-to-face and distant medicine:

$$\tilde{x} = \min\{\max\{0; \frac{\Delta d + \alpha_e p_e - \alpha_c p_c}{t}\}; L\} \quad (4.2)$$

with $\Delta d = d_c - d_e$. We can write the physicians' profits as

$$\Pi_A = p_c \tilde{x} \quad (4.3)$$

and

$$\Pi_B = p_e (L - \tilde{x}). \quad (4.4)$$

Physicians maximize their respective profits simultaneously and we characterize the corresponding solution in Lemma 5:

LEMMA 5. (*Specialized duopoly, solution*)

1. When $0 \leq 2tL \leq d_c - d_e$:

- $p_c = \frac{\Delta d - tL}{\alpha_c}$; $D_c = L$; $\Pi_A = \frac{\Delta d - tL}{\alpha_c} L$
- $p_e \geq 0$; $D_e = 0$; $\Pi_B = 0$
- $\Pi_A + \Pi_B = \frac{\Delta d - tL}{\alpha_c} L$
- $CS = L(d_e + \frac{tL}{2})$; $PE = \frac{1 - \alpha_c}{\alpha_e} (\Delta d - tL)L$

2. When $d_c - d_e \leq 2tL \leq d_c + 2d_e$:

- $p_c = \frac{tL + \Delta d}{3\alpha_c}$; $D_c = \frac{tL + \Delta d}{3t}$; $\Pi_A = \frac{(tL + \Delta d)^2}{9\alpha_c t}$
- $p_e = \frac{2tL - \Delta d}{3\alpha_e}$; $D_e = \frac{2tL - \Delta d}{3t}$; $\Pi_B = \frac{(2tL - \Delta d)^2}{9\alpha_e t}$
- $\Pi_A + \Pi_B = \frac{(tL + \Delta d)^2}{9\alpha_c t} + \frac{(2tL - \Delta d)^2}{9\alpha_e t}$
- $CS = \frac{t}{2} (\frac{tL + \Delta d}{3t})^2 + \frac{L}{3} (d_c + 2d_e - 2tL)$; $PE = \frac{1 - \alpha_c}{\alpha_c} \frac{1}{t} (\frac{\Delta d + tL}{3})^2 + \frac{1 - \alpha_e}{\alpha_e} \frac{1}{t} (\frac{2tL - \Delta d}{3})^2$

3. When $d_c + 2d_e \leq 2tL$:

- $p_c = \frac{d_c}{2\alpha_c}$; $D_c = \frac{d_c}{2t}$; $\Pi_A = \frac{(d_c)^2}{4\alpha_c t}$
- $p_e = \frac{d_e}{\alpha_e}$; $D_e = \frac{2tL - d_c}{2t}$; $\Pi_B = \frac{d_e(2tL - d_c)}{2\alpha_e t}$
- $\Pi_A + \Pi_B = \frac{1}{2t} (\frac{d_c^2}{2\alpha_c} + \frac{d_e(2tL - d_c)}{\alpha_e})$
- $CS = \frac{d_c^2}{8t}$; $PE = \frac{1 - \alpha_c}{\alpha_c} \frac{1}{t} (\frac{d_c}{2})^2 + \frac{1 - \alpha_e}{\alpha_e} \frac{1}{t} d_e \frac{2tL - d_c}{2}$

To be complete, we have to consider $d_e - \alpha_e p_e < 0$ as well. However, from B 's perspective, $d_e - \alpha_e p_e < 0$ is always dominated by $d_e - \alpha_e p_e \geq 0$. Therefore, B will never choose p_e such that $d_e - \alpha_e p_e < 0$ and we can thus ignore this subcase.

LEMMA 6. (*Specialized duopoly, interpretation*)

There is no medical desert if two physicians specialize in either face-to-face or distant medicine. The fee is not necessarily higher for face-to-face visits as compared to distant medicine. It is the case only if unit transportation costs and total distance are sufficiently low. Both the fee and the demand for face-to-face [distant] medicine increase [decrease] in the value of in-person medicine, d_c , and it decreases [increases] in the value of distant medicine, d_e . Patients' fees, $\alpha_c p_c$ and $\alpha_e p_e$, as well as demands are independent on co-payments. Both physicians provide medicine only when transportation costs and distance are high enough. The fee for face-to-face medicine weakly increases [decreases] and the consumer surplus decreases [increases] in tL when the latter is high [low] enough. The fee for telemedicine is set so as to fully extract consumer surplus, if and only if tL is high enough. Public expenses are increasing in total distance, L .

Lemmata 5 and 6 establish that with a specialized duopoly, medical deserts are not an issue anymore. All patients receive care, whether in-person or remotely, and total demand corresponds to the length of the geographical area.

The first part of Lemma 5 corresponds to a situation where distant medicine does not attract a single patient because distances and transportation costs are low and the differential in diagnostic values is high. The fee for face-to-face medicine however is lower here than under the benchmark case where physician A provides face-to-face medicine without any competition from distant medicine. The reason is that now, there is a possibility for the competitor to supply distant medicine if the fee for face-to-face medicine were higher. There is thus a latent competitive pressure.

Furthermore, we observe that for such low levels of tL , p_c and Π_A are decreasing in tL in a specialized duopoly, while they would be increasing in tL in a standard duopoly. The reason is related to the nature of competition that is not standard in the present case. In a standard duopoly, an increase in transportation costs would make the competitors less substitutable with each other, leading to increased market power (with higher fees and profits). In a specialized duopoly instead, with distant medicine, an increase in transportation costs or in maximum distance would make distant medicine more attractive, increasing therefore the latent competitive pressure and resulting in a lower market power for face-to-face medicine (with lower p_c and Π_c).

The second part of Lemma 5 is the only one that points to a fee for distant medicine that does not fully extract surplus from the furthest consumers. The reason is that, unlike in the third part of Lemma 5, these furthest consumers are not that distant, tL having intermediate values here. The competitive pressure between face-to-face and distant medicine is therefore not latent but concrete here.

The fees for distant medicine are not always lower than fees for face-to-face medicine, anymore. For instance, in part 2 of Lemma 5, we can have $p_c - p_e < 0$ when $\alpha_c = \alpha_e$ and $2tL = d_c + 2d_e$ while $p_c - p_e > 0$ when $\alpha_c = \alpha_e$ and $2tL = d_c - d_e$. The differential in diagnosis qualities continues favoring relatively high fees for in-person medicine. However, distance and transport costs play in the opposite direction. To understand this, we consider part 2 of Lemma 5, which corresponds to the interior solution of the simultaneous maximization problem. In such a case, the reaction functions associated to maximizing profits (4.3) and (4.4) and leading to the interior solution are as follows:

$$p_c = \frac{(d_c - d_e) + \alpha_e p_e}{2\alpha_c} \quad (4.5)$$

and

$$p_e = \frac{tL - (d_c - d_e) + \alpha_c p_c}{2\alpha_e}. \quad (4.6)$$

Given that the quality of diagnosis is higher for in-person than for distant medicine, it is in the best interest of physician A to provide in-person medicine at a fee increasing in $(d_c - d_e)$. The opposite is true for the physician providing distant medicine. Furthermore, higher distance and travel cost play in favor of distant medicine. Therefore, it is in the best interest of physician B to increase her fee as tL increases. Depending on how $(d_c - d_e)$ compares with tL and on the difference between co-payments, we have a fee for distant medicine that can be lower or higher than that for in-person medicine.

5. OVERALL COMPARISON

To appreciate whether a physician should either supply both face-to-face and distant medicine or specialize in either type of medicine, we proceed to an overall comparison of the three cases we have analyzed so far. We have already established that distant medicine in our setting always solve the issue of medical deserts, no matter who provides it, either physician A or B . We therefore focus on the fees, the demand for face-to-face medicine, D_c , and the overall consumer surplus, CS . We now use the superscripts M , $M2$ and D to refer to the cases of a monopoly with face-to-face medicine only, a monopoly with both face-to-face and distant medicine and a duopoly, respectively. Lemma 7 characterizes the overall comparison:

LEMMA 7. (*Overall comparison*)

1. $L = D_c^{M2} + D_e^{M2} = D_c^D + D_e^D \geq D_c^M$
2. $p_e^D \leq p_e^{M2}$
3. $p_c^D \leq p_c^M \leq p_c^{M2}$
4. $CS^D \geq CS^M \geq CS^{M2}$
5. When either $\alpha_c \geq \alpha_e$, or $\alpha_c \leq \alpha_e$ and $d_c + (2 - 3\frac{\alpha_c}{\alpha_e})d_e \leq 2tL$, then
 - $D_c^{M2} \leq D_c^D \leq D_c^M$
6. When $\alpha_c \leq \alpha_e$ and $d_c + (2 - 3\frac{\alpha_c}{\alpha_e})d_e \geq 2tL$, then
 - $D_c^D \leq D_c^{M2} \leq D_c^M$

We observe that the specialized duopoly leads to the lowest fees and the highest consumer surplus, which is very intuitive. The competitive pressure is effective indeed. The opposite applies for a multitask monopoly since price discrimination is implemented.

If we focus our attention on public expenses, we can show that lowest public expenses can be combined with maximum consumer surplus under a specialized duopoly if, for

$\alpha_c > \alpha_e$, we have $2tL \leq \tilde{y}$, where $\tilde{y} \in (d_c - d_e; d_c + 2d_e)$. If transportation cost t or distance L are larger then public expense is minimal if there is a single physician providing only face-to-face health services. We identify here a first effect to interpret how public expenses compare across market structures. When t and L are relatively low, medical deserts are not an issue. In such a case, a specialized duopoly is cheaper than a simple monopoly in terms of public expenses, because of the competitive effect of the duopoly, which leads to lower prices and expenses. If instead, t and L are higher, then the duopoly covers a larger population, which becomes more expensive in terms of public health insurance reimbursements. Considering now that the share of the fees paid by patients is higher for distant medicine ($\alpha_e > \alpha_c$), we can observe how the multitask monopoly compares with the other two market structures in terms of public expenses. Here a second effect comes into play, which is a direct one. When the patients' co-payment for distant medicine is relatively high, the multi-task monopoly is relatively inexpensive in terms of public expenses, because patients pay the bulk of total expenses when t and L are high, and conversely. Combining the two effects explain why the ranking of market structures regarding public expenses vary with the parameters, as stated in the following lemma.⁵

LEMMA 8. (*Overall comparison of public expenses*)

1. *In general, public expenditure PE are lowest with either a specialized duopoly or a single monopoly providing face-to-face medicine only:*

- $PE^D \leq PE^M \iff 2tL \leq \tilde{y} \in (d_c - d_e; d_c + 2d_e)$
- $PE^D \geq PE^M \iff 2tL \geq \tilde{y} \in (d_c - d_e; d_c + 2d_e)$

2. *There are two particular parameter configurations for which public expenses are lowest with a multitask monopoly:*

- $\alpha_c \leq 2\alpha_e - 1 \leq \alpha_e$, $\alpha_c(2\alpha_e - 1 - \alpha_c) \geq 4\alpha_e(1 - \alpha_e)$ and the value of tL is intermediate
- $\alpha_e = 1$ and the value of tL is intermediate or high

6. THE EFFECT OF DIFFERENTIATED COPAYMENTS

In all cases but one, the effect of copayments is typical of models where demand is linear: the prices that maximize providers' profits always adjust to copayments in such a way that both demands and patients' prices (αp) are invariant to copayments.⁶ The reason is the following. Copayments have a direct influence on both consumers' fees (positive effect) and demands (negative effect). Moreover, the provider(s) charge higher prices when the co-payment rate is lower, taking advantage of a lower price elasticity of demand when the co-payment is lower. Therefore, through prices, copayments have also an indirect effect on both consumers' fees and demands, which is opposite to the direct effects. With linear demands, both direct and indirect effects cancel out and both consumers' prices

⁵Proof in Appendix 9.2.

⁶See Jelovac and Bordoy (2005) for an illustration in the case firms decide pharmaceutical prices. This result does not hold anymore when prices are negotiated, see Jelovac (2015a).

and demands are invariant to copayments. Consequently, in all cases but one, consumer surplus is invariant to copayments while profits decrease in copayments.

However, we find one exception to such regularity. Indeed, part (ii) of Lemma 3 states that a monopolist who provides both distant and face-to-face medicine sets prices in a more sophisticated way. The part of the fee that is paid by patients for face-to-face visits is increasing in α_c and decreasing in α_e . So is the demand for distant medicine, while the opposite holds regarding demand for face-to-face medicine. When a single physician offers both face-to-face and distant medicine and if the demand for each type is strictly positive, then the price of face-to-face medicine is always higher than the price of distant medicine. The physician's interest is to keep face-to-face patients. Then facing variation in α_e (or d_e), the physician must adjust the price of clinical examination either to take advantages of an higher distant medicine price or, alternatively, to avoid patient's switch from face-to-face to distant medicine.

7. DISCUSSIONS

We have so far presented a very simple yet flexible model to discuss how distant medicine can influence medical fees, patients' surplus and public expenses according to the prevalent market structure. Despite some limitations, which we discuss later on, simplicity and flexibility of such a model have an important advantage in terms of applications to concrete situations. Our results, even if complete and rigorously derived, should not be applied as a ready-to-use receipt to evaluate any policy change, without a specific adaptation to the corresponding reality. This section adapts our model to discuss a recent policy change in France as well as a concrete issue related to the availability of cross-border telemedicine.

7.1. Policy change in France

Since the beginning of the Covid pandemics, the French health authority has decided that distant medicine should be totally reimbursed. In our setting, this corresponds to the special value of our parameter $\alpha_e = 0$, while the out-of-pocket payment rate for face-to-face medicine remained at around 30% of medical fees ($\alpha_c = 0.3$). Moreover, the French legislation does not allow distant medicine to account for more than 20% of each physician's total medical activity. This automatically rules out our duopolistic specialized market structure where physician B only provides distant medicine. Our model allows to predict the effect of a change in reimbursement rules, starting from July 31, 2022: rather than being total, the reimbursement rate for distant medicine becomes partial and equal to the one applied to face-to-face medicine. In our model, this corresponds to $\alpha_c = \alpha_e = 0.3$. In the initial situation with $\alpha_e = 0$, our analysis predicts that a monopoly physician would set relatively high fees for both distant and face-to-face medicine. Indeed, the physician can take advantage of a full reimbursement of his fee for distant medicine to set such a fee at a very high level without discouraging demand for distant medicine. He would accordingly set his fee for face-to-face medicine at such a level that only 20% of the patients' population chooses distant medicine while the others opt for face-to-face medicine. Formally, $\tilde{x} = 0.8L$ and $d_c - 0.3p_c - 0.8tL = d_e$, which is equivalent to p_e very high and

$$p_c = \frac{d_c - d_e - 0.8tL}{0.3} \tag{7.1}$$

A move towards partial reimbursement of both distant and face-to-face medicine ($\alpha_c = \alpha_e = 0.3$) likely results in lower prices for both types of medicine, because a physician cannot take advantage of a full reimbursement for distant medicine anymore. Therefore, demands would readjust, increasing the one for face-to-face medicine and decreasing the one for distant medicine. All together we expect that, after July 31, 2022, total demand remains constant and both fees decrease. We therefore expect lower public expenditure but lower patients' surplus as well because of poorer reimbursements.

7.2. Cross-border distant medicine

In the main part of this article, we assume that the value of face-to-face diagnosis is always higher than the value of online examination. Explanations are for examples poor audio/video connections or photo quality, increased possibility of misdiagnosis because a clinical examination is missing and security breaches. Now we consider the opposite situation to illustrate a specific issue. For example, Mayo Clinic health system, ranked at or near the top overall hospital in the United States, provides telehealth for US patients as well as international patients. From an international perspective, such cross-border care is not covered by the public health system. This can be reflected in our analysis by having distant medicine offered abroad only and setting the specific values: $\alpha_e = 1 > \alpha_c$ and $d_e > d_c$. Profit maximization in the specialized duopoly case leads to the following solution.

1. When $0 \leq tL \leq d_e - d_c$:

- $p_c = 0$; $D_c = 0$; $\Pi_A = 0$
- $p_e = d_e - d_c$; $D_e = L$; $\Pi_B = (d_e - d_c)L$
- $CS = d_cL$; $PE = 0$

2. When $d_e - d_c \leq tL$:

- $p_c = \frac{tL - (d_e - d_c)}{3\alpha_c}$; $D_c = \frac{tL - (d_e - d_c)}{3t}$; $\Pi_A = \frac{(tL - (d_e - d_c))^2}{9\alpha_c t}$
- $p_e = \frac{2tL + (d_e - d_c)}{3}$; $D_e = \frac{2tL + (d_e - d_c)}{3t}$; $\Pi_B = \frac{(2tL + (d_e - d_c))^2}{9t}$
- $CS = \frac{t}{2} \left(\frac{tL - (d_e - d_c)}{3t} \right)^2 + \frac{L}{3} (d_c + 2d_e - 2tL)$; $PE = \frac{1 - \alpha_c}{\alpha_c} \frac{1}{t} \left(\frac{tL - (d_e - d_c)}{3} \right)^2$

The second situation is similar to the duopoly case analyzed previously (see part 2 of Lemma 5). Comparing with the solution in Lemma 1, we observe that the existence of telemedicine leads to a decrease in price for face-to-face medicine and demand is lower except if tL is sufficiently high ($tL > \frac{d_c}{2} + d_e$) or if the value of telemedicine diagnosis is not really high.

The interesting and new situation is the first one: face-to-face medicine ceases to exist and all patients virtually visit the cross-border distant physician. In such a case public expenses are nil. In this case, the fee for face-to-face medicine is reduced to 0 and even so none of the patients visits the face-to-face provider, because of the high quality differential $d_e - d_c$. Compared to the monopoly situation, consumer surplus is increased with the presence of telemedicine, even without health insurance reimbursements.

8. CONCLUSION

In this paper we explore how telemedicine influences physicians' pricing decisions both in a monopolistic setting and in a competitive one. We consider a setup where telemedicine can be provided by the same physician as face-to-face medicine or by an independent one and we highlight how consumer surplus and public expenses are affected by these different types of competition. Our results show that telemedicine fights against medical desert, either in a monopoly or in a specialized duopoly case. The interests of consumers are best served in the duopoly situation thanks to the competition between providers while price discrimination implementing in monopoly case allows to fully extract the surplus from distant patients.

The comparison of public expenses is based on two effects: one which is related to transportation cost and distances and the other linked to patient co-payments. The former effect reveals that public expenses are less important in duopoly case due to the competition between providers (leading to lower prices) only if t and L are relatively low. For increased values, public health insurance reimbursements are more expensive with duopoly since it covers a larger population. The second effect discloses that if the co-payment for distant service is low then public expenses are relatively expensive in the dual monopoly case because reimbursements are generous. For an increased value of co-payment for distant medicine, patients pay the bulk of total expenses when t and L are high and multitask monopoly becomes relatively inexpensive.

We adapt our flexible model to discuss a recent policy change in the French health care system. While distant medicine has been totally reimbursed until July 2022, we expect that the recent increase in co-payment for such distant medicine to generate lower fees for both types of health services, a lower patients' surplus and lower public expenses. Another adaptation of our model allows us to qualify the circumstances under which high-quality cross-border care can replace in-person medicine, even without health insurance.

Our results rest on a model that is restrictive on several grounds. First, we do not consider any capacity constraint while the working time of physicians is not unlimited. Second, the quality of diagnoses is exogenous and it is not costly for the physicians. Last, we assume that the health care providers have similar abilities to obtain market power. Avenues for future research may consider relaxing such assumptions.

9. APPENDIX

9.1. Proof of Lemma 3

9.1.1 Telemedicine is better than nothing

We first impose that $d_e - \alpha_e p_e \geq 0$. That is, all patients prefer to pay for telemedicine rather than seeing no physician at all. The indifferent patient between face-to-face and distant medicine is located at

$$\tilde{x}_2 = \text{Min}\{\text{Max}\{0; \frac{\Delta d + \alpha_e p_e - \alpha_c p_c}{t}\}; L\}. \quad (9.1)$$

with $\Delta d = d_c - d_e$. We can thus write the physician's profit as

$$\Pi_A = p_c \tilde{x}_2 + p_e (L - \tilde{x}_2). \quad (9.2)$$

The candidates for a solution are:

1. Candidate 1

- $p_c > \frac{d_c}{\alpha_c}$
- $p_e = \frac{d_e}{\alpha_e}$
- $D_c = 0$
- $D_e = L$
- $\Pi_A = \frac{d_e}{\alpha_e} L$

2. Candidate 2

- $p_c = \frac{(\alpha_c - \alpha_e)\Delta d - (\alpha_e + \alpha_c)tL}{(\alpha_c - \alpha_e)^2}$
- $p_e = \frac{(\alpha_c - \alpha_e)\Delta d - 2\alpha_c tL}{(\alpha_c - \alpha_e)^2}$

The conditions for the demands D_c and D_e to be within the range $[0; L]$ are the following: $d_c - \alpha_c p_c - tL \leq d_e - \alpha_e p_e \leq d_c - \alpha_c p_c$.

These two conditions cannot hold simultaneously with such price candidates. Therefore, we rule out Candidate 2.

3. Candidate 3

- $p_c = \frac{\alpha_e d_c + \alpha_c d_e}{2\alpha_c \alpha_e}$
- $p_e = \frac{d_e}{\alpha_e}$
- $D_c = \frac{\alpha_e d_e - \alpha_c d_e}{2\alpha_e t}$
- $D_e = L - \frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e t}$
- $\Pi_A = \frac{d_e}{\alpha_e} L + \frac{1}{\alpha_c t} \left(\frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e} \right)^2$

The conditions for the demands D_c and D_e to be within the range $[0; L]$ are the following: $0 \leq \alpha_e d_c - \alpha_c d_e \leq 2\alpha_e tL$

4. Candidate 4

- $p_c = \frac{d_c - tL}{\alpha_c}$
- $p_e = \frac{d_e}{\alpha_e}$
- $D_c = L$
- $D_e = 0$
- $\Pi_A = \frac{d_c - tL}{\alpha_c} L$

The condition for the price to be non-negative is the following: $tL \leq d_c$.

Analysis: Candidate 3 dominates Candidate 1 and Candidate 3 dominates Candidate 4. Candidates so far for Subsection 3.2 dominate the outcomes of Subsection 3.1. Moreover, when $d_e - \alpha_e p_e \leq 0$, then we obtain the same outcomes as in Section 3.1, see hereafter.

9.1.2 Nothing is better than telemedicine

Now we consider that $d_e - \alpha_e p_e \leq 0$, meaning that the poor quality of distant medicine is not worth its price. The solution to the profit maximization is the same as the results obtained in Section 3.1. These outcomes are always dominated by the candidates specified above.

9.2. Proof of Lemma 8

For the sake of comparison, it is important to bear in mind that

$$\alpha_c < \alpha_e \implies 0 < d_c - d_e < d_c - \frac{\alpha_c}{\alpha_e} d_e < d_c < d_c + 2d_e$$

and

$$\alpha_c > \alpha_e \implies 0 < d_c - \frac{\alpha_c}{\alpha_e} d_e < d_c - d_e < d_c < d_c + 2d_e.$$

From there we directly compare the public expenses PE corresponding to the relevant ranges.⁷ Some comparisons are straightforward as for example the comparison of PE when

$$d_c - \frac{\alpha_c}{\alpha_e} d_e < 2tL < d_c - d_e$$

In such a case, expressions of PE are the following:

- $PE^M = \frac{1-\alpha_c}{\alpha_c} (d_c - tL)L$,
- $PE^{M2} = (1 - \alpha_c) \frac{\alpha_e d_c + \alpha_c d_e}{2\alpha_c \alpha_e} \frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e t} + (1 - \alpha_e) \frac{d_e}{\alpha_e} (L - \frac{\alpha_e d_c - \alpha_c d_e}{2\alpha_e t})$
- $PE^D = \frac{1-\alpha_c}{\alpha_c} (\Delta d - tL)L$.

Direct comparison leads to $PE^M > PE^D$.

Moreover, we can write,

$$PE^{M2} - PE^M = \frac{1}{4t} [2tL - (d_c - \frac{\alpha_c}{\alpha_e} d_e)] [(1 - 2\alpha_e + \alpha_c) \frac{d_e}{\alpha_e} - \frac{1 - \alpha_c}{\alpha_c} (d_c - 2tL)].$$

The first part of this expression for $PE^{M2} - PE^M$ is positive since $2tL > d_c - \frac{\alpha_c}{\alpha_e} d_e$. The second part can be rewritten as

$$\frac{1 - \alpha_c}{\alpha_c} (2tL - (d_c - \frac{\alpha_c}{\alpha_e} d_e)) + \frac{d_e}{\alpha_e} (2\alpha_c - 2\alpha_e),$$

which is always positive.

Therefore, under the parameter configuration $d_c - \frac{\alpha_c}{\alpha_e} d_e < 2tL < d_c - d_e$, public expenses compare as follows

$$PE^{M2} > PE^M > PE^D.$$

⁷Details of computations are available upon request.

Other comparisons are more sophisticated. For example, when $\alpha_c > \alpha_e$ and $d_c - d_e < 2tL < d_c + 2d_e$, expressions of tPE^D and tPE^M (we multiply PE by t for notational ease) are the following:

- $tPE^M = \frac{1-\alpha_c}{\alpha_c}(d_c - tL)L$ if $d_c - d_e < 2tL < d_c$,
- $tPE^M = \frac{1-\alpha_c}{\alpha_c} \frac{(d_c)^2}{4}$ if $d_c < 2tL$,
- $tPE^D = \frac{1-\alpha_c}{\alpha_c} \left(\frac{d_c-d_e+tL}{3}\right)^2 + \frac{1-\alpha_e}{\alpha_e} \left(\frac{2tL-d_c+d_e}{3}\right)^2$

We first compare these expressions at the boundaries:

$$tPE^D(2tL = d_c - d_e) < tPE^M(2tL = d_c - d_e)$$

and

$$tPE^D(2tL = d_c + 2d_e) > tPE^M(2tL = d_c + 2d_e).$$

It is easy to show that tPE^D and tPE^M are increasing in $2tL$.

Also, tPE^D is convex in $2tL$ whereas tPE^M is concave.

Then we can conclude that there exists $\tilde{y} \in (d_c - d_e; d_c + 2d_e)$ such that

$$PE^D \leq PE^M \iff 2tL \leq \tilde{y}$$

and

$$PE^D \geq PE^M \iff 2tL \geq \tilde{y}.$$

The comparison of tPE^{M2} with tPE^M and tPE^D is based on the same reasoning.

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