Hospital financial incentives and nonprice competition*

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January 12, 2015

Comments welcome.

Abstract

We study the interplay between reimbursement incentives and nonprice competition in the hospital industry. Accounting for strategic interactions and equilibrium effects, we derive comparative statics results for hospital responses to changes in reimbursement rates. We then estimate a structural model of hospital choice over a period of four years when stronger incentives have been gradually placed on a subset of hospitals in France. We explain how the hospitals have changed the gross utility supplied to patients, depending on their exposure to competition. The results suggest that the utilities supplied by hospitals are strategic complements.

JEL Codes: I11; I18; L33.

Keywords: Hospital financial incentives; nonprice competition; travel costs; patient demand.

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*We are grateful to Kurt Brekke, Pierre Dubois, Randall Ellis, Philippe Février, Robert Gary-Bobo, Nicolas Jacquemet, Laurent Linnemer, Albert Ma, Michael Manove, Florence Naegelen, Gérard de Pouvourville, Denis Raynaud, Luigi Siciliani, Alain Trannoy, Michael Visser and Engin Yilmaz for insightful comments. We thank seminar participants at Boston University, UC Santa Barbara, Toulouse School of Economics, CREST Paris, the French Ministry of Health and INSEE, as well as the CESIfo Applied Micro 2013 Conference (Munich), the EARIE and EEA 2013 conferences (Evora and Göteborg), the ESEM 2014 conference (Toulouse), and the "Journée Chaire Santé" workshop (University of Paris 9).

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1 Introduction

Payment system reforms in many advanced countries have placed hospitals under stronger financial incentives. One of the channels through which incentives affect hospital behavior is competition, specifically nonprice competition when prices are set by a regulator. In assessing the welfare consequences of payment reforms, researchers therefore need to take market competition into account, and often use for this purpose hospital concentration indicators based on observed patient flows. Yet, as noted by Kessler and McClellan (2000), patient flows are themselves outcomes of the competitive process. How patient flows evolve as hospital reimbursement incentives become stronger is the subject of the present article.

In our empirical application, the incentives placed on government-owned and other nonprofit hospitals have been gradually strengthened as their funding moved from global budgeting to patient-based payment. For the concerned hospitals, an extra admission generated no additional revenue prior to the reform while it did thereafter. During this period, the financial rules applying to for-profit, private clinics have remained unchanged. These hospitals, however, may have been indirectly affected by the reform due to strategic interactions.

Both our theoretical analysis and empirical analysis follow a competition-in-utility-space approach, whereby the utility supplied to patients is the relevant strategic variable. We investigate how hospital responses to higher reimbursement rates depend on their own characteristics and on their competitive environment. To this aim, we build a nonprice competition model where hospitals compete in utility to attract patients. We describe the economic forces that tend to make utilities strategic complements or strategic substitutes. Unlike previous research,[1] our focus is on deriving comparative statics results for oligopoly when the (possibly different) reimbursement rules that apply to each hospital change. As is the case in our empirical application, we assume that the reimbursement rates per admission increase for a subset of the hospitals in the market and remain unchanged for the others. We examine the direct effect of stronger incentives on the utility supplied by a hospital subject to the reform, and investigate how these effects propagate across hospitals in equilibrium.

We find that the hospitals subject to the reform on average increase the utility provided to patients by more than the other hospitals, which we call the "average relative effect" of the reform. Most importantly, we show that the exposure to

[1] See, e.g., Pope (1989), Ellis (1998), Brekke, Siciliani, and Straume (2011), and Gravelle, Santos, and Siciliani (2014).

competition affects equilibrium responses differently depending on whether the utilities supplied to patients are strategic complements or strategic substitutes. Under strategic complementarity, we find that within both subsets the proximity of hospitals (not) subject to the reform magnifies (attenuates) the response to the reform. The effects are reversed under strategic substitutability. We also show that among hospitals subject to the reform those with a higher marginal utility of income respond more vigorously.

We test these predictions using panel data on all surgery admissions in France during the phase-in period of the considered policy reform. Our primary variable of interest is the evolution of gross utility or hospital "attractiveness" or "desirability", which we see as the empirical counterpart of the changes in utility examined in the theoretical model. We infer the *changes* in gross utilities from the observed evolution of market shares. We place structure on utility variations that allows us to check the predictions from theory that have been stated above.

Our structural model of hospital choice places the emphasis on the spatial aspect of competition, taking advantage of the richness of the data in this dimension. We indeed observe about 37,000 distinct patient locations in the data. Our estimation strategy does not rely on any restriction of the patient choice sets, but on differences in differences in both the spatial dimension and the time dimension.

The econometric results provide evidence that nonprice competition has been at work as reimbursement incentives have become stronger for nonprofit hospitals. After the full implementation of the reform, we find an average relative effect of about two minutes –about 9.3% of the median travel time. Patients are ready to travel two minutes more after the reform than before to seek treatment from a hospital that has been subject to the reform. In other words, the catchment areas of hospitals subject to the reform have increased on average by 2 minutes relative to those of hospitals not subject to the reform.

Our main findings, however, concern the effect of competition, and they strongly suggest that the utilities supplied to patients are strategic complements. To measure exposure to competition from hospitals, we use indicators based on distance-weighted numbers of surgery beds at neighboring hospitals at the start of reform. A one standard-deviation increase in exposure to competition from hospitals subject to the reform *increases* the hospital responses by about 2 minutes, a magnitude similar to that of the direct effect. Similarly, one standard-deviation increase in exposure to competition from hospitals *not* subject to the reform *decreases* the responses by about 2 minutes. These effects differ according to whether the concerned hospital is itself subject to the reform (stronger effect) or not (weaker effect). Overall, we find a pretty strong complementarity between competition forces and the change in payment incentives.

Finally, we use the debt ratio at the start of the reform as a proxy for marginal utility of income because more indebted hospitals presumably are in greater need of extra revenues. We indeed find that these hospitals have reacted more vigorously to the reform. A one standard-deviation increase in a hospital debt ratio increases the response by about .4 minute.

The paper is organized as follows. Section 3 provides industry background, describes the policy reform, and provides reduced-form evidence. Section 4 presents the theoretical framework. Section 5 presents our data set. In Section 6, we expose our structural model of hospital choice and the estimation strategy. Section 7 checks how the results fit with theory. Section 8 concludes.

2 Related literature

A great deal of attention has recently been devoted to the impact of policy reforms and/or market structures on clinical quality or productive efficiency, see Gaynor and Town (2012) and Gaynor, Ho, and Town (Forthcoming). As a recent example, Gaynor, Propper, and Seiler (2012) who investigate how hospital quality has been affected by a policy reform that has increased patient choice in the United Kingdom, and for this purpose construct a measure of hospital mortality that is corrected for patient selection.[2] We depart from this set of papers by not relying on clinical quality indicators, but instead inferring changes in hospital attractiveness from the evolution of patient flows and local market shares. In this respect, our work is perhaps more closely related to Gowrisankaran, Lucarelli, Schmidt-Dengler, and Town (2013) who estimate the impact of the Medicare Rural Flexibility Program on the demand for inpatient services. These authors, however, do not address hospital competition which is key in the present work.

A couple of issues about hospital choice and demand estimation are worth mentioning. First, as most existing studies we do not model the underlying decision process which in practice involve many others parties (medical staff, relatives)

[2]Others articles using mortality or complication rates are Cutler (1995), Shen (2003), Cooper, Gibbons, Jones, and McGuire (2011) and Propper (2012). Varkevisser, van der Geest, and Schut (2012) rely on quality ratings made available to patients by the Dutch government. In a different vein, Herwartz and Strumann (2012) uses both Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) to assess hospital performance.

than the patient itself. An important exception is Ho and Pakes (2014) who study physician incentives in the referral process for birth deliveries in California.

Second, many of the above mentioned studies rely assumptions on how long patients consider traveling to visit a hospital, then checking robustness of their findings to the adopted assumptions. By contrast, we do not rely on any restriction of patient choice sets. In particular, travel costs are estimated through an original "triangulation approach" that exploits the very high number of distinct patient locations in the data set.

Third, while many studies focus on one or a couple of specific procedures or diagnosis,[3] we aggregate the data at the level of clinical department (e.g. orthopedics, stomatology, etc.) and are interested to estimate the extent to which each hospitals has become more attractive (in relative terms) following the policy reform in each of these departments . At this level of aggregation, the upcoding issue studied by Dafny (2005) is less of an issue because upcoding mostly affects assignment to diagnosis-related groups (DRG) within a clinical department.

Finally, the study is also related to the literature on hospital ownership. Duggan (2000) examines a change in the government financing policy that has encouraged hospitals to treat low-income individuals, and finds that public hospitals have been unresponsive to financial incentives. The reason is that any increase in their revenues were taken by the local governments that own them. The logic at work in the present study is strikingly different as the reform in question has unambiguously given public hospitals stronger marginal incentives to attract patients.

3 Industry background and payment reform

In France, more than 90% of hospital expenditures are covered by the public and mandatory health insurance scheme. Supplementary insurers (including the state-funded supplementary insurance for the poor) cover much of the remaining part.[4] For instance, supplementary insurers generally cover the fixed daily fee that hospitals charge for accommodation and meals. On the other hand, they may not fully cover some extra services (e.g. individual room with television) that some consumers may want to pay for, or extra-billings that certain prestigious doctors may charge. Although as Ho and Pakes (2014) we do not observe patient

[3] For examples, Tay (2003), Gaynor, Propper, and Seiler (2012), Ho and Pakes (2014) respectively consider heart attack, Coronary Artery Bypass Graft, birth deliveries.

[4] In 2010, 96% of French households were covered by supplementary health insurance.

Table 1: Hospitals – Summary Statistics

	Subject to the reform hospitals ($\mathcal{S}$) Gov.-owned		Private nonprofit		Together		Not subject ($\mathcal{N}$) For-profit clinics		Total Total	
# of hospitals	477		111		588		565		1,153	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
# stays in 2005	3,763.1	(5,250.1)	2,181.2	(2,334.5)	3,464.5	(4,874.1)	5,459.7	(3,570.0)	4,442.2	(4,397.8)
# stays in 2006	3,855.8	(5,416.9)	2,232.5	(2,449.3)	3,549.3	(5,032.1)	5,531.6	(3,608.3)	4,520.7	(4,501.1)
# stays in 2007	3,896.9	(5,493.6)	2,293.6	(2,511.9)	3,597.0	(5,107.6)	5,446.5	(3,597.8)	4,503.3	(4,526.1)
# stays in 2008	4,032.6	(5,737.1)	2,393.2	(2,627.9)	3,725.9	(5,332.7)	5,382.2	(3,638.0)	4,537.6	(4,653.6)
# stays (2008 - 2005)	273.8	(662.5)	208.0	(551.3)	261.4	(643.0)	-77.4	(1130.6)	95.4	(930.2)
	Beds and unused capacity in 2004									
# beds	100.7	(153.2)	58.1	(60.1)	92.7	(141.5)	80.4	(46.6)	86.6	(105.3)
Unused Capacity	33.9	(50.9)	25.9	(27.1)	32.4	(47.4)	34.6	(21.2)	33.5	(36.7)
	Exposure to competition in 2004									
comp^N	0.220	(0.351)	0.383	(0.467)	0.250	(0.380)	0.314	(0.423)	0.282	(0.404)
comp^S	0.154	(0.246)	0.323	(0.310)	0.185	(0.267)	0.261	(0.291)	0.223	(0.281)
	Debt ratio									
Debt / total assets	0.357	(0.162)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source. French PMSI, individual data, 2005-2008.
Sample. 1,153 hospitals in mainland France.
Note. Financial information available for 441 government-owned hospitals only. Unused capacity in thousands bed-days.

individual out-of-pocket expenses in the data, we know from the National Health Accounts that, at the aggregate level, out-of-pocket expenses have remained low and stable during our period of study (the four years 2005 to 2008), accounting for only 2.9%, 3.1%, 3.1%, and 3% of total hospital expenditures during these four successive years.

The present study restricts attention to surgery, which accounts for about 35% of hospital acute-care admissions in medical, surgical and obstetrics departments. As regards surgery, the structure of the hospital industry has remained constant over the period of study. Our dataset includes all hospitals that offer surgery services in mainland France, namely $1,153$ hospitals, among which 477 are government-owned, 111 are private nonprofit hospitals, and 565 are private, for-profit clinics, see Table 1. The surgery bed capacity of a government-owned hospital is generally slightly higher than that of for-profit clinic (101 versus 80), and government-owned hospitals account for a higher share of the total capacity at the national level than for-profit clinics (48% versus 45%). The 111 private nonprofit hospitals are generally smaller and account for the remaining 6% of the aggregate bed capacity. A for-profit clinic has generally much more patient admissions than a government-owned hospitals (5,500 versus 4,000), and all for-profit clinics together represent about 60% of all surgery admissions.

The payment reform The shift from global budgeting to activity-based payment for French hospitals has been designed in 2002 and has involved successive stages. The "reform" considered in this paper consists of one of these stages, that occurred between 2004 and 2008 and concerned only a fraction of the hospitals.

The reform applied to the set, hereafter denoted by $\mathcal{S}$, of all nonprofit hospitals, either government-owned or private. Before March 2004, these hospitals were funded through an annual lump-sum transfer from the government (*"global dotation"*) which varied very little with the nature or the evolution of their activity. The payment rule has gradually been moved to an activity-based payment, where activity is measured by using (successive versions of) a DRG classification as is standard in most developed countries. For the concerned hospitals, activity-based revenues accounted for 10% of the resources in 2004, the remaining part being funded by a residual dotation. The share of the budget funded by activity-based revenues increased to 25% in 2005, 35% in 2006, 50% in 2007 and finally to 100% in 2008. The residual dotation has then been totally suppressed in 2008.[5]

Before 2005, private, for-profit clinics were already submitted to a prospective payment based on DRG prices. The reimbursement rates, however, included a *per diem* fee: as a result, they depended on the length of stay. Moreover, these rates were negotiated annually and bilaterally between the local regulator and each clinic, and were consequently history- and geography-dependent. Starting 2005, all for-profit clinics are reimbursed the same rate for a given DRG and those rates no longer depend on length of stay.[6]

In sum, between 2005 and 2008, the payment rule applying to private, for-profit clinics has been constant, while nonprofit hospitals have been submitted to increasingly strong reimbursement incentives. Hereafter we denote by $\mathcal{N}$ the set of private, for-profit clinics. Although these clinics have not been subject by the reform, they may have been affected indirectly through strategic market interactions.

Reduced-form evidence From Table 1, it is easy to check that hospitals in $\mathcal{S}$ accounted for 39.8% (41.9%) of all surgery admissions in 2005 (2008). Figure 1 confirms that the number of admissions in hospitals subject to the reform

[5] A series of lump-sum transfers have subsisted, some of which are linked to particular activities such as research, teaching or emergency services, while others have more distant connections to specific actions. In 2007, the various transfers accounted for 12.7% of resources.

[6] The DRG-based reimbursement schemes are different in both level and scope for hospitals in $\mathcal{S}$ and in $\mathcal{N}$. In the latter group, DRG rates do not cover physician fees, which are paid for by the health insurance system as in the community market.

increased more rapidly over the period than the admissions in for-profit clinics. This supplementary increase amounted to $197,000$ stays.

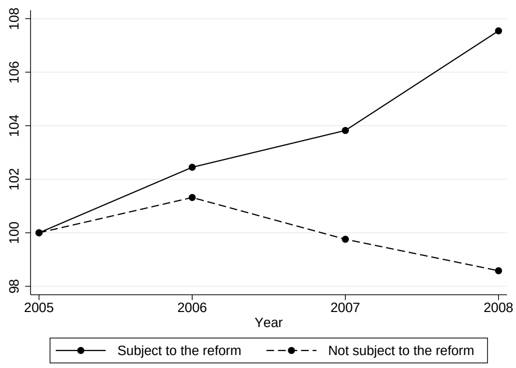


Figure 1: Evolution of the number of surgery admissions (Years 2005 to 2008)

Table 2 shows an increase in volumes of 24.2 stays per hospital, per clinical department and per year at nonprofit hospitals relative to for-profit clinics between 2005 and 2008.

Table 2: Difference in differences (per hospital and clinical department)

		2005		2008		2008 – 2005	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Number of stays	Not subject to the reform (N)	399.5	(8.2)	409.4	(8.7)	-4.2	(2.5)
	Subject to the reform (S)	256.2	(6.5)	279.9	(7.1)	20.0	(1.3)
	S-N	-143.2	(10.4)	-129.5	(11.2)	24.2	(2.7)

Source. French PMSI, individual data, 2005-2008.
Sample. 1,153 hospitals in mainland France.
Note. Number of stays per hospital, clinical dept, year.

4 Theoretical framework

In this section, we set up a general model of nonprice competition and explain how a change in the reimbursement policy affects the utility provided by each hospital in equilibrium. We then establish comparative statics properties for utility changes in a linear framework. These properties will be tested empirically in the remainder of the paper.

4.1 General model

Throughout the paper, we adopt a discrete-choice framework where a consumer's net utility from treatment is the sum of a hospital specific term and an idiosyncratic patient-level shock:

$$U_{ih} = u_h + \zeta_{ih}. \tag{1}$$

As put by Armstrong and Vickers (2001) when presenting the competition-in-utility-space approach, we can think of u_h as the "average" utility offered by firm h to the population of consumers. Patients may be heterogenous in various dimensions, with the corresponding heterogeneity ζ_{ih} entering utility in an additive manner. We hereafter place the emphasis on one particular dimension of heterogeneity, namely patient location, and on the resulting implications for spatial competition. We assume that hospitals do not discriminate across patients according to location; more generally, we assume away any discrimination based on patient characteristics.

Individual demand at the patient level is obtained by choosing the hospital that yields the highest value of U_{ih} in (1). As is standard in the hospital literature, we do not consider the option of not receiving treatment. (We come back to this important issue in Section 6.) Integrating over the disturbances ζ_{ih}, we obtain the aggregate demand addressed to hospital h, $s^h(u_h, u_{-h})$, which depends positively on the utility supplied by that hospital, and negatively on the set of utilities supplied by its competitors. Normalizing the total number of patients to one, the demand function can be interpreted in terms of market shares or of number of patient admissions.

We assume that the hospitals receive a payment from the government according to some linear reimbursement rule: hospital h receives a lump-sum transfer $\bar{R}_h$ plus a payment per discharge $r_h \geq 0$. For now, we make no restriction on the hospitals' objective functions, V^h. Let $\mu^h = \partial V^h / \partial u_h$ denote hospital h's perceived marginal incentive to increase the utility offered to patients. The first-order conditions are obtained by setting those incentives equal to zero

$$\mu^h(u_h, u_{-h}; r_h, \bar{R}_h) = 0. \tag{2}$$

The above condition implicitly defines hospital h's reaction function, which we denote by $u_h = \rho^h(u_{-h}; r_h, \bar{R}_h)$. The second-order conditions require that $\partial \mu^h / \partial u_h < 0$ for all hospitals.

In this oligopoly setting, an equilibrium is characterized by the solution to the system (2). In a general study on comparative statics under imperfect competition, Dixit (1986) separately provides necessary conditions and sufficient conditions for equilibrium stability. The simplest set of sufficient conditions is obtained by requiring strict diagonal dominance for the Jacobian matrix $\mathrm{D}_u\mu$ with generic entry $\partial\mu^h/\partial u_k$.

Following Dixit's methodology, we investigate how the equilibrium varies with the reimbursement rates r_h. For the moment, we keep the lump-sum transfers $\bar{R}_h$ fixed.[7] In carrying out the comparative statics exercise, we assume that the objective function V^h does not change as the payment system is reformed. In particular, there is no crowding-out of intrinsic motives due to more powerful financial incentives. Only the shape of the profit function changes as a result of the reform. Finally, we assume that the managers' time horizon is short due for instance to high job mobility, implying that the hospital objective only depends on current outcomes.

Differentiating each of the first-order condition $\mu^h = 0$ with respect to r_h yields

$$\frac{\partial\mu^h}{\partial u_h}\mathrm{d}u_h + \frac{\partial\mu^h}{\partial u_{-h}}\mathrm{d}u_{-h} + \frac{\partial\mu^h}{\partial r_h}\mathrm{d}r_h = 0. \tag{3}$$

We define the *direct effect* of the change in r_h on the utility supplied by hospital h as the effect that would prevail in the absence of strategic interaction, i.e., if the utilities supplied by the competitors, u_{-h}, were fixed:

$$\Delta_h\mathrm{d}r_h = \frac{\partial u_h}{\partial r_h}_{|du_{-h}=0}\mathrm{d}r_h = -\frac{\partial\mu^h/\partial r_h}{\partial\mu^h/\partial u_h}\,\mathrm{d}r_h. \tag{4}$$

We denote by Δ the diagonal matrix with Δ_h on its diagonal. The vector $\Delta\mathrm{d}r$ measures the effect of the changes in the reimbursement rates on hospital utilities if strategic interactions were neutralized.

To obtain the equilibrium effect, the direct effects need to be "expanded" as follows. For $h \neq k$, we denote by F_{hk} the opposite of slope of the reaction function ρ^h in the direction k, i.e.

$$F_{hk} = -\frac{\partial\rho^h}{\partial u_k}_{|dr=0} = \frac{\partial\mu^h/\partial u_k}{\partial\mu^h/\partial u_h}. \tag{5}$$

Setting $F_{hh} = 1$, we introduce the matrix F with generic entry F_{hk},[8] as well as its

[7] The role of the lump-sum transfers is discussed in Section 4.5.

[8] To illustrate, in a simple example with four hospitals, the matrix F takes the form given by (A.1).

inverse $T = F^{-1}$. Rearranging (3), we get

$$\mathrm{d}u = T\Delta\,\mathrm{d}r. \tag{6}$$

The transmission matrix T summarizes how the direct effects $\Delta\mathrm{d}r$ propagate through the whole set of strategic interactions between hospitals to yield the equilibrium outcome. The generic element of T, which we denote hereafter by t_{hk}, can be seen as a pass-through rate, expressing the extent to which the direct effect on hospital h translates into a higher utility offered by hospital k in equilibrium.

Under the policy reform considered in the present article, the reimbursement rates r_h increase for a subset of hospitals, which we denote by $\mathcal{S}$, and are left unchanged for the other hospitals. The complementary set of $\mathcal{S}$ is denoted by $\mathcal{N}$. Although direct effects exist only for hospitals in $\mathcal{S}$, the hospitals in $\mathcal{N}$ are indirectly affected by the reform via the equilibrium effects embodied by the transmission matrix T. Formally, $\mathrm{d}r_h > 0$ for hospitals subject to the reform ($h \in \mathcal{S}$), and $\mathrm{d}r_h = 0$ for hospitals not subject to the reform ($h \in \mathcal{N}$). The changes in equilibrium utilities are given by

$$\mathrm{d}u_h = \sum_{k\in\mathcal{S}} t_{hk}\,\Delta_k\,\mathrm{d}r_k. \tag{7}$$

In the empirical part of the paper, we infer the utility changes $\mathrm{d}u_h$ from the evolution of patient flows as reimbursement incentives were being strengthened for nonprofit hospitals (recall the description of the payment reform in Section 3). The right-hand side of the fundamental formula (7), however, depends on fine details about hospital characteristics and market geography. Hereafter, we identify economic forces that shape the direct effects $\Delta_k dr_k$ and the transmission coefficients t_{hk} and we derive comparative statics properties under a simple specification. The structure we place on utility variations in the econometric model of Section 6 is closely related to these properties.

4.2 Linear incentives

As noted by Dixit, it is hard to impose a structure on the inverse matrix T, and "progress can only be made by looking at particular forms of product heterogeneity, and using the resulting special structures of the coefficient matrix." The structure of that matrix depends on the specific form of the hospital objectives and on the shape of the patient demand. We address these issues in turn.

As commonly done in the health care literature (see e.g. Ma (1994), Brekke, Siciliani, and Straume (2012)), we model the objective function of each hospital h as a function of profit, non-pecuniary costs and altriusm. as a separable function of profit π, number of patient admissions s, gross utility offered to patients u, and cost-containment effort e:

$$V^h(\pi, s, u, e) = \lambda_h \pi - \frac{b_h}{2} u^2 - \frac{w_h}{2} e^2 + (v_h + a_h u)\, s. \tag{8}$$

The hospital profit is the difference between revenues $\bar{R}_h + r_h s$ and total pecuniary costs

$$C^h(s, u, e) = F_h + (c_{0h} - e + c_h u)\, s \tag{9}$$

consisting of a fixed part F_h and a variable part $(c_{0h} - e + c_h u)\, s$. The marginal pecuniary cost per admission, $c_{0h} - e + c_h u$, is constant and linearly increasing in the utility offered to patients. The middle terms in the objective function V^h represent the non-pecuniary costs of managerial efforts to raise the utility supplied to patients and to lower the hospital marginal cost.[9] The last two terms in (8) represent non-financial motives to attract patients. Hospital managers may value the number of patient admissions, perhaps because hospital activity has positive spillovers on their future careers. This motive is reflected in third term $v_h s$ of (8). The term $a_h u s$ expresses the altruistic motive, whereby manager and staff enjoy providing high utility to patients.[10]

When λ_h equals zero, financial profits do not enter the hospital objective; cost-containment efforts are zero, and the hospital chooses u_h that maximizes the function $(v_h + a_h u_h)\, s^h(u_h, u_{-h}) - b_h u_h^2/2$ which we assume to be quasi-concave in u_h. For positive values of λ_h, the hospital manager puts a positive weight on financial performances. The limiting case of infinitely high λ_h corresponds to pure profit-maximization and does not seem at first glance well-adapted to describe the objective of nonprofit hospitals. In fact, those hospitals were subject to global budgeting ($r_h = 0$) prior to the reform and hence would have had no incentives at all to attract patients in the pre-reform regime if they were pure profit-maximizers.

The hospitals simultaneously choose cost-containment effort and the level of gross utility offered to patients. By the envelope theorem, the perceived marginal

[9]This specification assumes that the cost of managerial efforts is additively separable in e and u. Considering a more general function would complicate the analysis without bringing further insights.

[10]The same gross utility u is offered to all treated patients. To simplify the exposition, we assume here as in Ellis (1998) that patient travel costs do not enter providers' objective functions.

utility to increase the utility offered to patients is given by

$$\begin{aligned}\mu^h(u_h, u_{-h}; r_h) &= \left[v_h - \lambda_h c_{0h} + \lambda_h r_h + \lambda_h e^h + (a_h - \lambda_h c_h) u_h\right] \frac{\partial s^h}{\partial u_h} \\ &\quad + (a_h - \lambda_h c_h) s^h - b_h u_h, \end{aligned} \tag{10}$$

where $e^h(u_h, u_{-h}) = \lambda_h s^h / w_h$ is the level of cost-containment effort chosen by hospital h.

The main challenge for theoretical analysis lies in the presence of the demand $s^h(u_h, u_{-h})$ and its derivative $\partial s^h/\partial u_h$ in the expression of the incentives μ^h. Under the empirical model of Section 6, we allow for many dimensions of individual heterogeneity, which make those terms complicated and algebraic computations impossible. To shed light on the empirical analysis, however, it is worthwhile considering a simpler demand structure for which comparative statics results can be obtained and the underlying economic intuitions can be well understood.

We consider in the remainder of this section a spatial competition model with a single dimension of patient heterogeneity, namely geographic location. Patient net utility from admission in a given hospital is the gross utility offered by that hospital net of linear transportation costs

$$U_{ih} = u_h - \alpha d_{ih},$$

where the parameter α reflects the tradeoff between the average gross utility offered by a hospital and the distance between that hospital and the patient home.[11] This is the special case of the additive model (1) where $\zeta_{ih} = -\alpha d_{ih}$. As Dafny (2009) or Gal-Or (1999), we use Salop (1979)'s circular city model of spatial differentiation to model patient demand. In some of our examples, it is important that the hospitals are not located in an equidistant manner along the circle.[12] We impose no restriction on the relative positions on the circle of the subsets $\mathcal{S}$ and $\mathcal{N}$: the two groups of hospitals can be intertwined in a complicated way. With patients uniformly distributed along the circle, the demand function is linear in u_h and u_{-h}, in particular $\partial s^h/\partial u_h = 1/\alpha$, implying that the marginal incentives μ^h are linear in u_h and u_{-h}.

[11] Multiplying all utilities u_h and the parameter α by the same positive factor does not change the consumer problem; in this simplified setting, these parameters are only identified up to a scale factor. This identification issue is not present in the structural model of Section 6.

[12] The following arguments only require that the market is covered and that hospitals are all active.

Direct effects Under the linear specification described above, the direct effect, defined in (4), is given by

$$\Delta_h \, \mathrm{d}r_h = \frac{\lambda_h \, \mathrm{d}r_h}{2(\lambda_h c_h - a_h) + \alpha b_h - \lambda_h^2/(\alpha w_h)} \tag{11}$$

for each hospitals subject to the reform, $h \in \mathcal{S}$. The denominator of the above ratio is of the sign of $-\partial\mu^h/\partial u_h$, hence positive by the second-order conditions. The direct effects are therefore positive: higher reimbursement rates encourage hospitals to increase the utility they supply to patients. (This force is related to the absence of income effects in the linear model, see the discussion in Section 4.5.)

Reaction functions The reaction function of hospital h, $u_h = \rho^h(u_{-h}; r_h, \bar{R}_h)$, depends only on the utilities offered by its left and right neighbors. It is actually linear in those two utilities, with slope

$$\rho_h = \frac{\lambda_h c_h - a_h - \lambda_h^2/(\alpha w_h)}{4(\lambda_h c_h - a_h) + 2\alpha b_h - 2\lambda_h^2/(\alpha w_h)}. \tag{12}$$

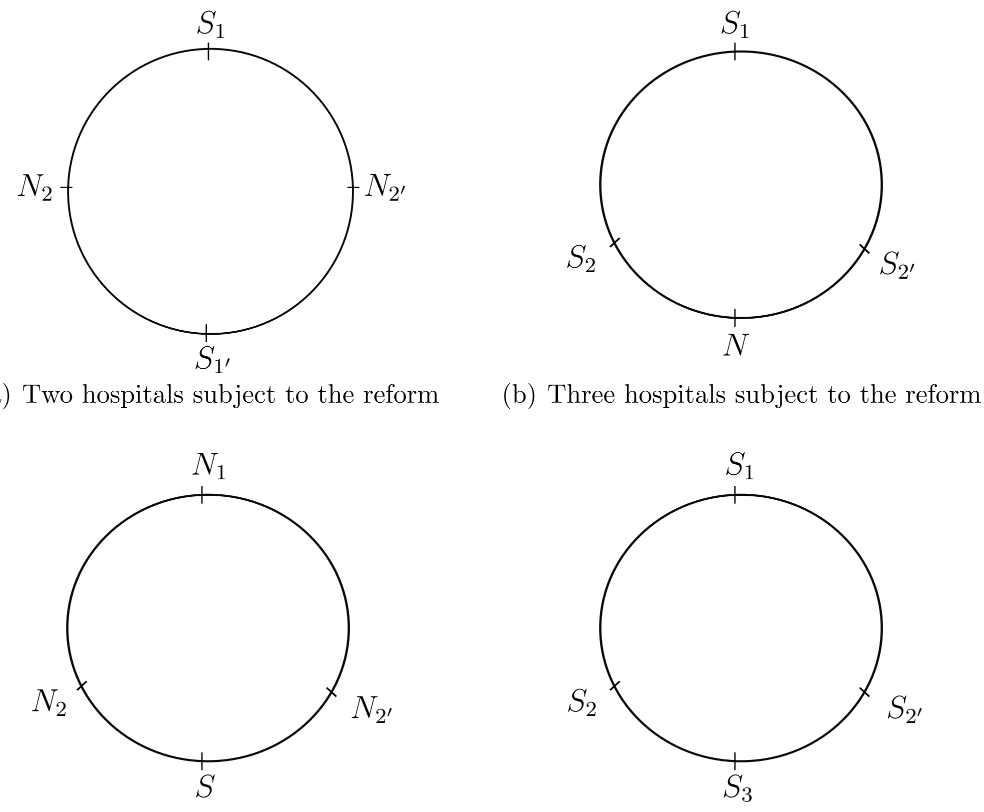
The matrix coefficient F_{hk} defined in (5) is equal to $-\rho_h$ if h and k are adjacent neighbors and to zero otherwise. We have already seen that the denominator is positive. It follows that the reaction function is upward-sloping if and only if $(\lambda_h c_h - a_h)/\alpha - \lambda_h^2/(w_h \alpha^2) > 0$. As explained by Brekke, Siciliani, and Straume (2014), the gross utilities offered to patients can be either strategic complements or strategic substitutes.

On the one hand, the costliness of quality pushes towards complementarity as in standard price competition. Because its total costs include the product $c_h u_h s^h$, see (9), hospital h finds it less costly to increase quality when u_{-h} increases and s^h decreases. Hospital h therefore has extra incentives to raise u_h, hence strategic complementarity. On the other hand, altruism and cost-containment effort push towards strategic substitutability. The intuitions for the latter two effects are as follows. As u_{-h} rises, fewer patients are treated by hospital h, hence a weaker altruism motive for that hospital to increase u_h; this effect materializes in the term $a_h s^h$ in (10). At the same time, the endogenous cost-containment effort, $e^h = \lambda_h s^h / w_h$, falls because the reduced marginal cost applies to fewer patient admissions, which, again, translates into weaker incentives μ^h as u_{-h} rises.[13]

[13] Formally, the fall in μ_h materializes in the term $\lambda_h e^h/\alpha = \lambda_h^2 s^h/(\alpha w_h)$ of equation (10) that decreases with u_{-h}.

4.3 Market geography

In this section, we investigate how the proximity of hospitals in $\mathcal{S}$ and in $\mathcal{N}$ affects a hospital's response to the reform. For this purpose, we assume that the preference parameters $a_h, b_h, c_h, \lambda_h, w_h$ are constant across hospitals. Assuming furthermore a uniform increase in the reimbursement rates, $\mathrm{d}r_h = \mathrm{d}r > 0$ in $\mathcal{S}$, we obtain that the direct effects given by (11) are the same for all hospitals subject to the reform, i.e., $\Delta_h \mathrm{d}r_h = \Delta \mathrm{d}r > 0$ for all h in $\mathcal{S}$. We then deduce from the fundamental equation (7) that $\mathrm{d}u_h$ is proportional to the sum of the transmission coefficients, $\sum_{k \in \mathcal{S}} t_{hk}$. We must therefore understand how this sum depends on the market configuration. To avoid uninteresting complications, we concentrate on market configurations with four hospitals. Any transmission coefficient t_{hk} can be written $t(0)$ if $h = k$, $t(1)$ if h and k are adjacent hospitals, $t(2)$ if a third hospital is interposed between h and k (see Appendix A for details).



(a) Two hospitals subject to the reform

(b) Three hospitals subject to the reform

(c) One hospital subject the reform

(d) Four hospitals subject the reform

Figure 2: Market configurations with four hospitals

Average relative effect We first establish that the hospitals subject to the reform ($h \in \mathcal{S}$) on average increase more their utility relative to the hospitals not subject to the reform ($h \in \mathcal{N}$). This property holds irrespective of whether the gross utilities supplied to patients are strategic complements or strategic substitutes:

$$\frac{1}{|\mathcal{S}|}\sum_{h\in\mathcal{S}} \mathrm{d}u_h - \frac{1}{|\mathcal{N}|}\sum_{k\in\mathcal{N}} \mathrm{d}u_k > 0, \tag{13}$$

where $|\mathcal{S}|$ and $|\mathcal{N}|$ denote the number of hospitals in $\mathcal{S}$ and $\mathcal{N}$. In the situation represented on Figure 2(a), we have $\mathrm{d}u_S = \mathrm{d}u_{S_1} = \mathrm{d}u_{S_{1'}} = t(0) + t(2)$ and $\mathrm{d}u_N = \mathrm{d}u_{N_2} = \mathrm{d}u_{N_{2'}} = 2t(1)$, so inequality (13) is equivalent to

$$\mathrm{d}u_S - \mathrm{d}u_N = [t(0) + t(2) - 2t(1)]\,\Delta\mathrm{d}r > 0. \tag{14}$$

When the utilities supplied by the hospitals are strategic complements, all three transition coefficients $t(0)$, $t(1)$, and $t(2)$ are positive, and all hospitals supply a higher utility following the reform. In Appendix A, we check that the function $t(.)$ is convex, which yields (14). When the utilities supplied by the hospitals are strategic substitutes, N_1 and N_2 respond to S_1 and S_2's utility increases by *decreasing* the utility they provide to patients. Technically, we find in Appendix that $t(0)$ and $t(2)$ are positive, while $t(1)$ is negative, making inequality (14) obvious. Inequality (13) is easy to check in the other configurations shown on Figure 2. Whether it can be established in more general environments is unknown to us. Under the econometric specification presented in Section 6, we find that the average relative effect of the reform (the left-hand side of (13)) is significantly positive, see Section 7.

Proximity of hospitals not subject to the reform Going beyond *average* relative effects, we now want to compare the relative effect of the considered reform *within* each of the two groups $\mathcal{S}$ and $\mathcal{N}$. We first investigate how the proximity of for-profit clinics in $\mathcal{N}$ affects the response of nonprofit hospitals in $\mathcal{S}$. To this aim, we consider the market configuration depicted on Figure 2(b), with three hospitals subject to the reform, S_1, S_2 and $S_{2'}$, symmetrically located on the circle, and a fourth hospital, N, not subject to the reform, interposed between S_2 and $S_{2'}$. The three hospitals subject to the reform are symmetric in any dimension but the proximity of a hospital not subject to the reform. The changes in gross utility by these three hospitals are $\mathrm{d}u_{S_1} = [t(0) + 2t(1)]\,\Delta\mathrm{d}r$ and $\mathrm{d}u_{S_2} = \mathrm{d}u_{S_{2'}} = [t(0) + t(1) + t(2)]\,\Delta\mathrm{d}r$, which yields the following difference in

Table 3: Comparative statics properties for utility changes $\mathrm{d}u_h$

	Under strategic complementarity		Under strategic substitutability	
	$h \in \mathcal{S}$	$h \in \mathcal{N}$	$h \in \mathcal{S}$	$h \in \mathcal{N}$
	(1)	(2)	(3)	(4)
A. Own unused capacity	$+^{(*)}$	-	$+^{(*)}$	-
B. Proximity and unused capacity of competitors $k \in \mathcal{N}$	-	-	+	+
C. Proximity and unused capacity of competitors $k \in \mathcal{S}$	$+^{(*)}$	$+^{(*)}$	$-^{(*)}$	-

Reading (cell B1): Under strategic complementarity, the response of hospital h in $\mathcal{S}$ (relative to that of other hospitals in $\mathcal{S}$) is lower when h is closer to hospitals k in $\mathcal{N}$ with larger unused capacities.
Cells B1 and B3 are based on the configuration of Figure 2(b). Cells C2 and C4 are based on that of Figure 2(c). Cells A1, C1, A3, and C3 are based on Figure 2(d). Cells A2, B2, A4, and B4 are based on Figure 4.
Note: (*) Assumes that the comparative statics regarding unused capacities is primarily governed by the direct effect.

utility changes between the hospitals:

$$\mathrm{d}u_{S_1} - \mathrm{d}u_{S_2} = \mathrm{d}u_{S_1} - \mathrm{d}u_{S_{2'}} = [t(1) - t(2)]\,\Delta \mathrm{d}r. \tag{15}$$

When the utilities supplied by the hospitals are strategic complements, we check in Appendix A that $t(1) > t(2) > 0$, implying then that the double difference $\mathrm{d}u_{S_1} - \mathrm{d}u_{S_{2'}}$ is positive: the proximity of the hospital in $\mathcal{N}$ attenuates the effect of the reform. On the contrary, when the utilities supplied by the hospitals are strategic substitutes, $t(1)$ is negative while $t(2)$ is positive, implying that the double difference is negative: being closed to a hospital in $\mathcal{N}$ magnifies the response of hospitals subject to the reform. These comparative statics properties are reported in cells B1 and B3 of Table 3.

Proximity of hospitals subject to the reform The proximity of hospitals in $\mathcal{S}$ plays in the opposite direction. Consider the configuration shown on Figure 2(c), namely three hospitals not subject to the reform, N_1, N_2 and $N_{2'}$, that are symmetrically located on the circle, and a fourth hospital subject to the reform, S, located between N_2 and $N_{2'}$. The three hospitals not subject to the reform are symmetric in any dimension but the proximity of a hospital subject to the reform. The changes in gross utility by these three hospitals are $\mathrm{d}u_{N_2} = \mathrm{d}u_{N_{2'}} = t(1)\Delta \mathrm{d}r$ and $\mathrm{d}u_{N_1} = t(2)\Delta \mathrm{d}r$, which yields $\mathrm{d}u_{N_2} - \mathrm{d}u_{N_1} = \mathrm{d}u_{N_{2'}} - \mathrm{d}u_{N_1} = [t(1) - t(2)]\,\Delta \mathrm{d}r$.

Utility changes are, again, ordered in the same way as $t(1)$ and $t(2)$. Under strategic complementarity (respectively substitutability), the proximity of a hospital in $\mathcal{S}$ is associated with a stronger (resp. weaker) rise in patient gross utility. These comparative statics properties are reported in cells C2 and C4 of Table 3.

4.4 Capacity utilization and hospital costs

In this section, we investigate how unused capacities at neighboring hospitals in $\mathcal{N}$ and in $\mathcal{S}$ affect a hospital's response to the reform. We argue that unused capacities are likely to be correlated with the cost parameters c_h and w_h, which themselves influence the magnitude of direct effects (for hospitals in $\mathcal{S}$) and the slopes of reaction functions.

Specifically, we assume below that a hospital finds it more costly to increase the utility it supplies to each patient and more difficult to reduce its marginal cost when it operates at, or close to, full capacity. The logic underlying this assumption is that when a hospital operates close to full capacity the staff is busy with everyday tasks, and therefore raising patient utility requires hiring new staff or having the existing staff work longer hours or changing organizational processes. The former two actions imply additional personnel expenses, while the latter two imply extra managerial efforts. When the managerial team has little time for thinking about innovations, efforts to improve patient experience or reduce marginal costs imply high non-pecuniary costs.

Remark 1. *Assume that the cost parameters c_h and w_h* decrease *with the margin of unused capacity. Then larger margins of unused capacity are associated with stronger direct effects (for h in $\mathcal{S}$) and lower slopes of the reaction functions.*

Proof. Considering first direct effects, we see from (11) that the magnitude of Δ_h decreases with c_h and w_h. The hospitals subject to the reform respond more vigorously to stronger incentives when these two costs parameters are lower. It then follows from Assumption 1 that the direct effect of the reform, $\Delta_h \mathrm{d}r_h$ for $h \in \mathcal{S}$, *increases* with the hospital's unused capacity. In other words, abstracting away from equilibrium effects, hospitals subject to the reform react more vigorously when they have larger amounts of unused capacity. This is very intuitive: a hospital that is already operating at full capacity has little incentive or ability to attract extra patients.

Turning to reaction functions, we check in Appendix A that the slope ρ_h, given by (12), *increases* with the cost parameters c_h and w_h. In other words, those hospitals that find it costly to increase utility and to reduce marginal costs react more vigorously to utility changes by their competitors. The intuition is as follows. When a competitor increases u_{-h}, hospital h faces a reduction in demand which has two consequences (recall Section 4.2): (i) the hospital finds it less costly to increase patient utility as the cost $c_h u_h s^h$ is reduced, hence an incentive to *rise* u_h, which is *stronger* for higher values of c_h; (ii) the hospital has a weaker incentive to reduce marginal costs (because $e^h = \lambda_h s^h / w_h$), hence a higher marginal cost and an incentive to *reduce* u_h; this effect, however, is *weaker* for higher values of w_h. Both channels, under Assumption 1, imply a lower ρ_h when h has more unused capacity. □

Unused capacities of hospitals in $\mathcal{N}$ We start by studying the role of unused capacities of hospitals that are not subject to the reform. These capacities operate through one single channel, namely the reaction function of the concerned hospitals.

To understand the impact of the unused capacity of a hospital in $\mathcal{N}$ on the response of neighboring hospitals in $\mathcal{S}$, we revisit the case of Figure 2(b) with three hospitals subject to the reform, S_1, S_2 and $S_{2'}$, and one for-profit clinic not subject to the reform, N. Assuming that the four hospitals have the same cost and preference parameters, we have seen above that the double difference $\mathrm{d}u_{S_1} - \mathrm{d}u_{S_2}$ is positive (negative) under strategic complementarity (substitutability). We now let clinic N have different parameters, maintaining the assumption that the three hospitals subject to the reform have the same cost and preference parameters, hence the same direct effect $\Delta \mathrm{d}r > 0$. We check in Appendix A that the *magnitude* of the double difference $\mathrm{d}u_{S_1} - \mathrm{d}u_{S_2}$ given by (15) increases (decreases) with N's unused capacity if $\rho_S > 0$ ($\rho_S < 0$). In other words, the effect of the proximity of clinic N is amplified by its amount of unused capacity. These results are reported in cells B1 and B3 of Table 3.

To understand the impact of the unused capacity of a hospital in $\mathcal{N}$ on its own response or on that of neighboring hospitals also in $\mathcal{N}$, we consider the configuration with five hospitals shown on Figure 4 in Appendix. (We use this more complicated configuration because we need a hospital in $\mathcal{S}$ for the reform to have an effect.) The results reported in cells A2 and A4 of Table 3 show that unused capacities at a hospital are associated with a weaker response of that hospital. The results in cells B2 and B4 express that large unused capacities at neighboring hospitals play in the same direction as the proximity of these hospitals (see the appendix for details).

Unused capacities of hospitals in $\mathcal{S}$ We now turn to the role of unused capacities of neighboring hospitals that are subject to the reform. The analysis is a bit more involved because these capacities operate through two channels, namely direct effects and reaction functions.

To understand the impact of the unused capacity of a hospital in $\mathcal{S}$ on the response of neighboring hospitals in $\mathcal{N}$, we consider the configuration shown on Figure 2(c), with three for-profit clinics not subject to the reform, N_1, N_2 and $N_{2'}$, and one nonprofit hospital subject to the reform, S. The larger S's unused capacity, the stronger the direct effect $\Delta \mathrm{d}r$ and the lower the slope of the reaction function, ρ_S. We find in Appendix that under strategic substitutability ($\rho_N < 0$) the double difference $\mathrm{d}u_{N_2} - \mathrm{d}u_{N_1}$ unambiguously decreases with S's unused capacity. If $\rho_N > 0$, the same monotonicity properties hold if we assume that the comparative statics analysis is driven by the change in the direct effect. These results are reported in cells C2 and C4 of Table 3.

Finally, to understand the impact of the unused capacity of a hospital in $\mathcal{S}$ on its own response or on that of neighboring hospitals also in $\mathcal{S}$, we consider the configuration shown on Figure 2(d), with four hospitals subject to the reform. We check in appendix that the double differences $\mathrm{d}u_{S_2} - \mathrm{d}u_{S_1}$, $\mathrm{d}u_{S_3} - \mathrm{d}u_{S_2}$ and $\mathrm{d}u_{S_3} - \mathrm{d}u_{S_1}$ increase with the magnitude of the direct effect for hospital S_3. This channel tends to make these differences increasing in the unused capacity of that hospital. These results are reported in cells A1, C1, A3 and C3 of Table 3.[14]

4.5 Marginal utilities of revenue

Heterogenous marginal utility of revenue To examine the impact of a hospital's marginal utility of revenue on its own response, we take the cost and preference parameters a_h, b_h, c_h and w_h as fixed. The second-order condition of the hospital problem is satisfied if and only if the denominator of (11) is positive. As already mentioned, when $\lambda_h = 0$, the program of hospital h boils down to $(v_h + a_h u_h)\, s^h(u_h, u_{-h}) - b_h u_h^2/2$ which is concave if and only if $\alpha b_h - 2a_h > 0$.

[14]Accounting for the heterogeneity in the cost parameter b_h leads to slightly less clear-cut results. It is natural to consider as in Remark 1 that b_h decreases with unused capacity. We find as above that direct effects decrease with b_h and hence increase h's unused capacity. The slope of the reaction function increases with b_h under strategic substitutability, which reinforces the property reported in columns (3) and (4) of Table 3. This slope, however, is decreasing in b_h under strategic complementarity, which may weaken the predictions reported in cells B2 and B4.

Under this assumption, we can let the marginal utility of revenue λ_h vary between zero and a maximum threshold, and we observe that the direct effect Δ_h increases with λ_h over this interval.[15] Following the same analysis as above (effect of own unused capacities, cells A1 and A3 of Table 3), we find that a higher marginal utility of revenue is associated with a stronger direct effect for hospitals h in $\mathcal{S}$, which tends to increase the response $\mathrm{d}u_h$ of those hospitals.

Income effects and budget-neutral reforms Under the linear specification adopted so far, the hospital marginal utility of revenue is exogenous, i.e., there is no income effect. The variations in hospital revenues induced by the reform have no impact on hospital behavior. For the same reason, the fixed parts of the reimbursement schedule, $\bar{R}_h$, $h = 1, \ldots, H$, play no role in the analysis.

In general, however, the presence of an income effect could reverse the reimbursement incentives, making the sign of Δ_h ambiguous. The indeterminacy is resolved if we restrict our attention to budget-neutral reforms. Starting from a situation where the lump-sum transfers $\bar{R}_h$ are all positive, we show in Appendix A that, for any given variations of the reimbursement rates, $\mathrm{d}r_h \geq 0$, there exist variations of the fixed transfers $\mathrm{d}\bar{R}_h$ such that the revenue of each hospital is the same before and after the reform.[16] In such an environment, where income effects are neutralized, the *direct* effect of the reform is positive, $\Delta_h \geq 0$: the hospitals subject to the reform are encouraged to increase the utility offered to patients, given the behavior of their competitors.

5 Data

The empirical analysis relies on two comprehensive administrative sources: *Programme de Médicalisation des Systèmes d'Information* and *Statistique Annuelle des Établissements de santé*. Both sources are based on mandatory reporting by each and any hospitals in France, and are thus exhaustive. The former contains all patient admissions in medical, surgical and obstetrics departments, providing in particular the patient home address and the DRG to which the patient stay has been assigned. The latter provides information about equipment, staff and

[15] The effect of λ_h on the slope of its reaction function, ρ_h, is not obvious as λ_h interacts with c_h and $1/w_h$ in (12).

[16] In the case of the French reform studied in this article, the regulator reduced the lump-sum transfers to limit as much as possible the induced variations in hospital revenues.

bed capacity. We also collected demographic variables at the French *département* level,[17] in particular average income and population stratified by age and gender.

The period of study is the phase-in period of the reform, namely the four years 2005 to 2008. The geographic area under consideration is mainland France, i.e., metropolitan France at the exclusion of Corsica. We drop out very small "local hospitals", which do virtually no surgery. We select patients coming from home including emergency cases (there is no reason to remove emergencies as they are part of activity of hospitals in both $\mathcal{N}$ and $\mathcal{S}$). We remove errors (invalid time or zipcodes), missing values and outliers from the data.[18] The sample contains about 5.2 million admissions per year.

5.1 Competition and financial indicators

We build competition indicators based on the proximity and the unused capacities (UC in short) of competitors, distinguishing whether the latter are or are not subject to the reform as exposed in Section 4.3. We define the following indicators of exposure to competition from hospitals respectively subject and not subject to the reform:

$$\mathrm{comp}_h^S = \sum_{k \neq h, k \in \mathcal{S}} e^{-\alpha d_{hk}} \mathrm{UC}_{k,04}/1000 \tag{16}$$

$$\mathrm{comp}_h^N = \sum_{k \neq h, k \in \mathcal{N}} e^{-\alpha d_{hk}} \mathrm{UC}_{k,04}/1000, \tag{17}$$

Our measure of unused capacity, $\mathrm{UC}_{k,04}$, is the difference between the maximal number and the actual number of patient nights for the year prior the reform. The maximal number of beds times is computed as the hospital surgery bed capacity multiplied by 366 nights. In words, for each hospital h, we count the amount of unused capacity in 2004 for all hospitals (separately in $\mathcal{S}$ or in $\mathcal{N}$) weighted by an exponentially decreasing function of the travel time to hospital h.

Travel times are expressed in minutes. We set the parameter α to .04, our preferred estimate of patient travel cost, see Section 7. It follows that 1,000 beds 25 minutes away from a hospital have a contribution of $\exp(-1) \approx .368$ to its exposure index.

[17]Mainland France is divided in 94 *départements* with about 650,000 inhabitants on average.

[18]With a travel time threshold of 150 minutes, we keep 98% of admissions. Some of the removed observations may correspond to patients who need surgery while on vacation far from their home.

Summary statistics for the competition indicators at the hospital level are presented in Table 1. The figures allow to assess the extent to which the average hospital h is exposed to competition from for-profit clinics ($k \in \mathcal{N}$) and from nonprofit hospitals ($k \in \mathcal{S}$). On average, in the sense of the proposed index, competition from for-profit clinics is slightly stronger than competition from nonprofit hospitals (.282 compared to .223). The decomposition by status of the considered hospital h allows to quantify inter-sector and intra-sector competition: the mean values .185 and .314 are measures of competition between respectively nonprofit hospitals and for-profit clinics ("intra-sector competition"), while the mean values .250 and .261 measure how hospitals in one sector are exposed to competition from hospitals of the other sector ("inter-sector competition"). We observe that on average nonprofit hospitals face less competition (from both sectors) than for-profit clinics. Finally, the inspection of standard errors show that the competition indices exhibit pretty large variations across hospitals.

As explained in the introduction, we use hospital debt ratio (debt over total assets) as a proxy for marginal utility of income. This indicator is available in the data for (almost all) government-owned hospitals but not for private clinics. This implies that the financial indicator is available for the vast majority of the hospitals in $\mathcal{S}$, but for no hospitals in $\mathcal{N}$. As shown on Table 1, debt represents 36% of assets for the average government-owned hospital, and the dispersion of that ratio is weaker than that of the competition indices.

5.2 Aggregation level

In the structural model of hospital choice presented below, we use the notion of clinical department rather than the DRG classification. Indeed, there are hundreds of DRGs that are abstract notions from the perspective of the patient –and even from that of general practitioners (GP) who address patients to hospitals. We believe that the notion of department is better adapted to describe hospital choice. For instance, a GP may trust a particular specialist physician, medical team or service within a given hospital, and that trust generally extends beyond a narrow set of DRG codes. The ten departments are orthopedics, ENT-stomatology, ophthalmology, gastroenterology, gynaecology, dermatology, nephrology, circulatory system, nervous system, cardiology.[19]

The purpose of this study is to assess the way hospitals have increased gross

[19]The shares of each department in number of surgery stays at the national level are shown in Table 13.

Table 4: Summary statistics at the (g, z, t) level

	Mean	S.D.
Number of patients	14.90	(79.46)
Number of hospitals	3.33	(4.59)
Number of observations (g, z, t)	1,392,775	

Source. French PMSI, individual data, 2005-2008.
Sample. 1,153 hospitals in mainland France.
Note. 1,392,775 zipcode × clinical department × year observations (20,753,308 discharges).

utility in response to a change in reimbursement incentives. We do not focus at patient heterogeneity except as regards distance to hospitals. We use postal zip codes to represent patient and hospital locations. There are about 37,000 patient zip codes in mainland France. A zip code, therefore, is much smaller than an administrative *département*. In rural areas, several cities may share the same zipcode; Paris, on the other hand, has 20 zip codes or *arrondissements*, and the second and third largest cities (Marseilles and Lyon) also have many zipcodes.[20] We define "demand units" as triples (clinical department, patient location, year) or (g, z, t) for which at least one patient admission occurred, i.e., $n_{gzt} > 0$. As shown in Table 4, the data set contains about 1.4 million demand units, and the average unit has 14.9 admissions in 3.3 distinct hospitals.

For each demand unit, we observe the number n_{ghzt} of admissions for all hospitals that receive patients from that unit, so $n_{gzt} = \sum_h n_{ghzt}$. The local share of hospital h in the demand unit (g, z, t) is $\hat{s}_{ghzt} = n_{ghzt}/n_{gzt}$. Table 5 presents the distribution of local share and travel time per admission (each (g, h, z, t) observation is weighted by the corresponding number of admissions). For less than 10% of the admissions, a single hospital serves all patients from the demand unit. The minimum local market share in the data is positive but lower than .0005. For more than 75% of admissions, the hospital and patient zip codes are different. The median and mean travel time between patient and hospital for an admission are respectively 22 and 27 minutes. Overall, the dispersion indicators (standard deviation, interquartile ratio) are relatively high for both local shares and travel times.

[20] All distances in the paper are based on the center of the corresponding zip codes, and are computed with INRA's Odomatrix software.

Table 5: Summary statistics at the (g,h,z,t) level

	Mean	S.D.	min	q10	q25	q50	q75	q90	max
Market share	0.322	(0.523)	0.000	0.038	0.120	0.278	0.474	0.667	1
Time (in minutes)	27.2	(54.7)	0.0	0.0	9.5	22.0	37.5	59.5	149.5
Number of observations $ghzt$					4,640,991				

Source. French PMSI, individual data, 2005-2008.
Sample. 1,153 hospitals in mainland France.
Note. 4,640,991 hospital × zipcode × clinical department × year observations (20,753,308 discharges) weighted by surgical discharges n_{hzgt}.

6 A structural model of hospital choice

In this section, we set up a structural model of hospital choice where patients face a tradeoff between travel time and gross utility provided by hospitals. First, we present the specification of the model and explain its relation to the theoretical framework of Section 4. Second, we discuss identification issues and explain the estimation strategy. Finally, we present the estimation results and test the predictions from the theory.

6.1 Econometric specification

We consider a patient i living in a zip code z seeking surgery care in clinical department g at date t. We model his/her net utility from undergoing treatment in hospital h as

$$U_{ighzt} = u_{ght} - \alpha d_{hz} + \xi_{ghzt} + \varepsilon_{ighzt}, \tag{18}$$

where d_{hz} denotes the travel time between patient home and hospital location.[21] This econometric specification is consistent with the general additive model (1), with $\zeta_{ighzt} = -\alpha d_{hz} + \xi_{ghzt} + \varepsilon_{ighzt}$.

The first term, u_{ght}, is the "average" utility index attached to a hospital, a clinical department, and a year, hence by definition constant across patients. The last two terms are statistical disturbances. The perturbations ξ_{ghzt} reflect deviations from mean attractiveness in patient area z. The perception of a hospital's attractiveness may indeed vary across patient locations, due to historical, administrative or economic relationships between the patient city and the hospital city, or for any other reason, e.g. general practitioners in a zip code may have particular connections to a given hospital h and tend to refer their patients to that hospital.

[21] We also include the square of travel time in an alternative specification. We also have estimated models where the parameter α depends on the year and on the clinical department.

Finally, the term ε_{ighzt} is an idiosyncratic shock at the patient level.

The time differences $u_{ght} - u_{gh2005}$ for $t > 2005$ are the empirical counterparts of the utility variations $\mathrm{d}u_h$ examined in Section 4, and hence our main object of interest. To express the variations of utility over the period in a concrete manner, we use the estimated parameter α as a conversion rate between utility and travel time. If a hospital increases gross utility, patients are ready to incur additional travel time to receive care from that hospital.

As seen in Section 4.2, theory suggests that the gross utilities supplied by the hospitals vary differently in $\mathcal{S}$ and in $\mathcal{N}$ over time. We therefore adopt the following specification of hospital attractiveness:

$$u_{ght} = \beta^S_{ht} S_h + \beta^N_{ht} N_h + \gamma X_{ht} + A_{gt} + B_{gh}, \tag{19}$$

where S_h and $N_h = 1 - S_h$ are dummy variables for being respectively subject and not subject to the reform. The difference between the respective means of β^S_{ht} and β^N_{ht} in the subsets $\mathcal{S}$ and $\mathcal{N}$ reflects the average relative effect of the reform, recall equation (13). We include time-varying, hospital-specific, exogenous variables X_{ht} to control for the evolution of local demand: population density, average income as well as age and gender stratification, all evaluated in the *département* where the hospital is located. To control for national trends in the utilization of hospital care, we include time-fixed effects A_{gt} at the clinical department level. Finally we also include hospital-clinical department fixed effects B_{gh} to account for the hospital reputation in each department.

To explain utility variations within each of the two groups $\mathcal{S}$ and $\mathcal{N}$, the theoretical analysis has highlighted the role of two variables: the proximity of other hospitals (either in $\mathcal{S}$ or in $\mathcal{N}$) and the marginal utility of revenue. We let β^S_{ht} and β^N_{ht} depend on these variables as follows:[22]

$$\begin{array}{rclclclcl} \beta^S_{ht} & = & \beta^{S0}_t & + & \beta^{SC}_t \mathrm{UC}_{h,04} & + & \beta^{SS}_t \mathrm{comp}^S_h & + & \beta^{SN}_t \mathrm{comp}^N_h \\ \beta^N_{ht} & = & & & \beta^{NC}_t \mathrm{UC}_{h,04} & + & \beta^{NS}_t \mathrm{comp}^S_h & + & \beta^{NN}_t \mathrm{comp}^N_h . \end{array} \tag{20}$$

For identifiability reasons, all the coefficients β_t are normalized to zero at the first year of the period ($t = 2005$), and there is no pure time effect β^{N0}_t in the expression of β^N_{ht}.

We have seen Table 3 Importantly the signs of coefficients β_t are predicted by Table 6. Adapting TO BE COMPLETED

[22] In some specifications, we let the various coefficients β depend on the clinical department g.

Table 6: Expected signs of coefficients in (20)

	Under strategic complementarity $h \in \mathcal{S}$ (1)	Under strategic complementarity $h \in \mathcal{N}$ (2)	Under strategic substitutability $h \in \mathcal{S}$ (3)	Under strategic substitutability $h \in \mathcal{N}$ (4)
A. Own unused capacity	$\beta_t^{SC} > 0$	$\beta_t^{NC} < 0$	$\beta_t^{SC} > 0$	$\beta_t^{NC} < 0$
B. Proximity and unused capacity of competitors $k \in \mathcal{N}$	$\beta_t^{SN} < 0$	$\beta_t^{NN} < 0$	$\beta_t^{SN} > 0$	$\beta_t^{NN} > 0$
C. Proximity and unused capacity of competitors $k \in \mathcal{S}$	$\beta_t^{SS} > 0$	$\beta_t^{NS} > 0$	$\beta_t^{SS} < 0$	$\beta_t^{NS} < 0$

In an extension, we let utility change in hospital subject to the reform depend on $\beta_t^{SF} F_h$ the absence of financial ratio for hospitals in $\mathcal{N}$ is due the unavailability of the variable in our data set.

6.2 Estimation approach

We assume that the patient idiosyncratic shock ε_{ighzt} is an i.i.d. extreme value error term, which yields the theoretical local market shares:

$$s_{ghzt} = \frac{e^{-\alpha d_{hz} + u_{ght} + \xi_{ghzt}}}{\sum_k e^{-\alpha d_{kz} + u_{gkt} + \xi_{gkzt}}}, \tag{21}$$

where the denominator includes all hospitals in mainland France.[23] The demand addressed to an hospital results from the integration against the distributions of the statistical disturbances ξ_{gkzt}.

A parametric estimation strategy consists in specifying those distributions and approximating the theoretical shares by numerical integration. This approach, however, would be computationally burdensome because of the high number of parameters to estimate, in particular more than 11,530 hospital fixed effects B_{gh} and 40 time-fixed coefficients A_{gt}. Moreover, this approach would require computing the distances between patient z and hospitals h even when h receives no patient from z. Given that the data set contains about 37,000 distinct patient zip codes z, the number of possible pairs (h, z) to consider would be very high.

We adopt instead a semi-parametric approach that relies on further exclusion restrictions, namely orthogonality assumptions regarding the local demand shocks, ξ_{ghzt}. We impose that these shocks are orthogonal to the market configuration,

[23] The identification issue in Footnote 11 is not present here: the level of α is identified by the implicit normalization of the variance of the ε_{ighzt}'s.

i.e., to the location of hospitals relative to that of patients and to whether or not they are subject to the reform:

$$\mathbb{E}\xi_{ghzt} = 0, \quad \mathbb{E}(\xi_{ghzt} \,|\, d_{h'z'}) = 0, \text{ and } \quad \mathbb{E}(\xi_{ghzt} \,|\, S_{h'}) = 0, \tag{22}$$

for all h, h', z, g, t. The market configuration is given by history: hospital locations have been decided many years before the period of study. Whether hospitals are subject to the reform depends on their for-profit versus nonprofit status, which also has been fixed for years. We thus consider these variables as exogenous over the period of study. The competition and financial indicators are evaluated in 2004 and are assumed to be orthogonal to demand or cost shocks that might occur after 2005.

A couple of issues in the estimation on demand model is the definition of individual choice sets. A first point in question concerns the option

is issue is As is standard in the literature, we do not consider the option of not going to any health care provider and we do not seek to guess the size of the potential demand –a parameter known to affect the estimates (Nevo, 2000). Following Tay (2003), Ho (2006) or Gowrisankaran, Lucarelli, Schmidt-Dengler, and Town (2011), we estimate the hospital choice model based on hospitalized patients, i.e., conditional on hospital admission. This is why only differences in attractiveness across hospitals are identified, hence the identifiability restrictions presented above.

Most existing studies restrict patient choice sets, typically defining geographic markets based on administrative boundaries (e.g. counties or states) or as the area within a given radius from the patient's home zip code or from a main city's center. For instance, Gowrisankaran, Lucarelli, Schmidt-Dengler, and Town (2011) and Gowrisankaran, Lucarelli, Schmidt-Dengler, and Town (2013) define, for each patient location, the "outside good" as the set of all hospitals outside a given radius and normalize the patient net utility for that good to zero. This leads to the standard Logit regression:

$$\ln s_{ghzt} - \ln s_{g0zt} = -\alpha d_{hz} + u_{ght} + \xi_{ghzt}, \tag{23}$$

where u_{ght} is given by (19). This method has the advantage of being easy to implement. The normalization of the outside good's utility, however, is not consistent with the definition of patient utility, equation (18). Furthermore, it generically implies a discontinuity in the patient net utility. As the distance to hospital rises, patient utility first linearly decreases, then brutally switches to zero when crossing the chosen cutoff radius. The discontinuity, which might well be *upwards* in some instances, is hard to justify. Finally, even if the orthogonality conditions (22) hold in the whole population, the estimation of (23) is based only on those observations with $s_{ghzt} > 0$. If a patient located at zipcode z gets treated in a distant hospital h, it might be because ξ_{ghzt} is large at that patient location, suggesting that, conditional on $s_{ghzt} > 0$, the variables d_{hz} and ξ_{ghzt} might be positively correlated. Such a correlation would generate a downward bias in the estimation of α. The researcher would mistakenly believe that patients do not dislike distance very much while in fact ξ_{ghzt} is high when hospital h and zipcode z are far apart.

We now suggest a method that partially addresses the above concerns.[24] We start by choosing a reference hospital $h^{\text{ref}}(z)$ in each zip code z. We use below the following definitions for that reference hospital: (i) the hospital with the highest number of surgery beds in the patient's *département*; (ii) the hospital in $\mathcal{S}$ with the highest number of surgery beds in the patient's *département*; (iii) the hospital in $\mathcal{N}$ with the highest number of surgery beds in the patient's *département*.[25]

We observe how the patient flows at the reference hospitals and the competing hospitals evolve over time. We can see whether the former gain (lose) market shares from (to) the latter by looking at the difference

$$\ln s_{ghzt} - \ln s_{gh^{\text{ref}}(z)zt} = -\alpha[d_{hz} - d_{h^{\text{ref}}(z)z}] + [u_{ght} - u_{gh^{\text{ref}}(z)t}] + [\xi_{ghzt} - \xi_{gh^{\text{ref}}(z)zt}]. \quad (24)$$

To estimate these equations, we compute the dependent variable by using the empirical counterparts of the local market shares, $\hat{s}_{ghzt} = n_{ghzt}/n_{gzt}$, where $n_{gzt} = \sum_h n_{ghzt}$ is the number of admissions in the demand unit gzt. The quality of the approximation of the theoretical share s_{ghzt} depends on the value of n_{gzt}, which is close to 15 on average, see Table 4. We have re-estimated the structural model after dropping out demand units with few patients, i.e., with a number of patients lower than a minimal threshold, and checked that the results are robust to that minimal threshold, see Table 12.

Travel costs The parameter α is identified by variations of local shares and distances in the zip code dimension. Indeed, consider the set of all zip codes z that

[24] The full resolution of the selection issue, however, is well outside the scope of the present applied study. For recent research on this difficult problem, see Gandhi, Lu, and Shi (2013).

[25] The three definitions of the reference hospital are different as the largest hospital in the *département* belongs to the subset $\mathcal{S}$ for 70 *départements* and to the subset $\mathcal{N}$ for 24 *départements*. See also Footnote 17.

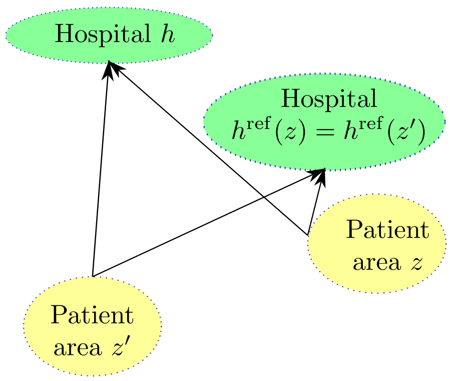


Figure 3: Double difference (in the zip code dimension) estimator

send patients to their reference hospitals $h^{\text{ref}}(z)$ and to another hospital h. Figure 3 shows two such zip codes, z and z'. The difference $u_{ght} - u_{gh^{\text{ref}}(z)t}$ is constant in this set and is eliminated by a within-transformation in the z dimension:

$$W^z \ln \frac{s_{ghzt}}{s_{gh^{\text{ref}}(z)zt}} = -\alpha W^z [d_{hz} - d_{h^{\text{ref}}(z)z}] + v_{ghzt}, \tag{25}$$

with $v_{ghzt} = W^z \left(\xi_{ghzt} - \xi_{gh^{\text{ref}}(z)zt} \right)$. The within-operator is defined as

$$W^z x_{ghzt} = x_{ghzt} - \frac{1}{|\mathcal{Z}_{hh^{\text{ref}}}|} \sum_{z' \in \mathcal{Z}_{hh^{\text{ref}}}} x_{ghz't},$$

where $\mathcal{Z}_{hh^{\text{ref}}}$ is the set of zipcode locations having a positive number patients admitted in hospitals h and $h^{\text{ref}}(z)$. When presenting the results, we indicate below the number of pairs $(h, h^{\text{ref}}(z))$ and the mean number of zipcodes per pair used for estimation. The direction of a potential selection bias is more ambiguous for equation (25) than it is for equation (23), because the possible positive correlation between d_{hz} and ξ_{hz} holds for both h and h^{ref} and the effect on the differences $d_{hz} - d_{h^{\text{ref}}(z)z}$ and $\xi_{hz} - \xi_{h^{\text{ref}}(z)z}$ is *a priori* unclear. Finally, we note that under this "triangulation" method, the identification of α comes from the z dimension, and therefore it is possible to estimate α for each clinical department and each year separately.

Utility variations By contrast, the changes in the gross utilities supplied by the hospitals are identified in the time dimension. Differentiating (24) between year t and year 2005 and using (19) and (20), we get

$$\begin{aligned}
\ln \frac{s_{ghzt} \big/ s_{gh^{\mathrm{ref}}(z)zt}}{s_{ghz,05} \big/ s_{gh^{\mathrm{ref}}(z)z,05}} &= \left(u_{ght} - u_{gh^{\mathrm{ref}}(z)t}\right) - \left(u_{gh,05} - u_{gh^{\mathrm{ref}}(z),05}\right) + w_{ghzt} \\
&= \beta_t^0 \left[S_h - S_{h^{\mathrm{ref}}(z)}\right] \\
&+ \beta_t^{SC} \left[S_h \mathrm{UC}_h - S_{h^{\mathrm{ref}}(z)} \mathrm{UC}_{h^{\mathrm{ref}}(z)}\right] \\
&+ \beta_t^{NC} \left[N_h \mathrm{UC}_h - N_{h^{\mathrm{ref}}(z)} \mathrm{UC}_{h^{\mathrm{ref}}(z)}\right] \\
&+ \beta_t^{SS} \left[S_h \mathrm{comp}_h^S - S_{h^{\mathrm{ref}}(z)} \mathrm{comp}_{h^{\mathrm{ref}}(z)}^S\right] \\
&+ \beta_t^{SN} \left[S_h \mathrm{comp}_h^N - S_{h^{\mathrm{ref}}(z)} \mathrm{comp}_{h^{\mathrm{ref}}(z)}^N\right] \\
&+ \beta_t^{NS} \left[N_h \mathrm{comp}_h^S - N_{h^{\mathrm{ref}}(z)} \mathrm{comp}_{h^{\mathrm{ref}}(z)}^S\right] \\
&+ \beta_t^{NN} \left[N_h \mathrm{comp}_h^N - N_{h^{\mathrm{ref}}(z)} \mathrm{comp}_{h^{\mathrm{ref}}(z)}^N\right] \\
&+ \beta_t^{SF} \left[S_h F_h - S_{h^{\mathrm{ref}}(z)} F_{h^{\mathrm{ref}}(z)}\right] \\
&+ \gamma \left[\left(X_{ht} - X_{h^{\mathrm{ref}}(z)t}\right) - \left(X_{h,05} - X_{h^{\mathrm{ref}}(z),05}\right)\right] \\
&+ w_{ghzt}, \qquad (26)
\end{aligned}$$

where $w_{ghzt} = \left(\xi_{ghzt} - \xi_{gh^{\mathrm{ref}}(z)zt}\right) - \left(\xi_{ghz,05} - \xi_{gh^{\mathrm{ref}}(z)z,05}\right), t \geq 2006$.

7 Results

Table 7 reports the estimation results of the regression equation (23) with a one-hour cutoff radius for the outside good. The disutility cost of an extra minute of travel time is estimated at .025. The proximity of hospitals (not) subject to the reform is associated with a stronger (weaker) increase in attractiveness, both for hospitals that are themselves subject to the reform and for hospitals that are themselves not subject to the reform. This suggests that the utilities supplied by the hospitals are strategic complement.

Next, we proceed with the estimation approach in difference relative to a reference hospital, (24). Table 8 shows the cost of travel time in the linear specification for the three choices of reference hospital, based on the triangulation approach, see (25). The number of observations for which the term $\ln s_{ghzt} - \ln s_{gh^{\mathrm{ref}}(z)zt}$ is defined at the right-hand side of (25) varies across reference hospitals. We find an estimated α of about .040, highly significant because of the very rich variation in the zip code dimension. This parameter varies little over time and across medical departments. The estimate found with the outside good approach, .025, may therefore be biased downwards (see the discussion in section 6.2).

Tables 10 and 14 present the estimations of (26) and confirm the predictions from theory regarding the proximities of other hospitals. The proximity of hospitals (not) subject to the reform is associated with a stronger (weaker) increase in attractiveness, both for hospitals that are themselves subject to the reform and not subject to the reform. Moreover, hospitals subject to the reform respond more strongly when they were more indebted (and therefore presumably had a higher marginal utility of revenue) at the start of the phase-in period.

In all specifications, average income and population density of the *département* contained in covariates X_{ht} turn out to have a significantly positive effect on u_{ght}.

Average relative effect of the reform Another prediction from the theory is that attractiveness u_{ght} increases more strongly for hospitals in $\mathcal{S}$ than for hospitals in $\mathcal{N}$, recall inequality (13). To express the average effect in terms of travel time, we compute the ratio

$$\tau^0_{gt} = \frac{1}{\hat{\alpha}_g}\left[\frac{1}{|\mathcal{S}|}\sum_{h\in\mathcal{S}}\left(\hat{u}_{ght} - \hat{u}_{gh,05}\right) - \frac{1}{|\mathcal{N}|}\sum_{k\in\mathcal{N}}\left(\hat{u}_{gkt} - \hat{u}_{gk,05}\right)\right],$$

and estimate its standard error by non-parametric bootstrap.[26] Table 13 shows the results evaluated at the end of the phase-in period, $t = 2008$. When the model is estimated for all surgery admissions, we find an average relative effect of about 1.8 minutes, which represents about 8.4% of the median travel time to hospitals for surgery admissions. We have also estimated the model separately for each clinical department, allowing all coefficients in (18), (19), and (20) to depend on g. We find that the average relative effect varies a lot across medical departments, roughly between 2% and 20% for most departments.[27] Table 11 yields the average relative effect for the different choices of reference hospitals, showing an effect comprised between 1.4 and 1.8 minutes. Table 12 shows that the estimated average relative effect does not change dramatically when demand units with a small number of patients are excluded from the sample. For instance, if we consider demand units with at least 20 patients ($n_{gzt} > 20$), the estimated effect is close to 1.2 minute.

[26] We proceed to 200 draws with replacement from the data set at the (g,h,z,t) level, estimate (25) and (26) in each of the replicated sample, and compute the standard deviation of the parameters of interest.

[27] The nervous system department is an outlier with a negative average relative effect.

Measuring competitive effects Among hospitals in $\mathcal{S}$, attractiveness increases more (less) rapidly for hospitals more exposed to competition from hospitals in $\mathcal{S}$ (in $\mathcal{N}$): $\beta_t^{SS} > 0, \beta_t^{SN} < 0$. The same is true among hospitals in $\mathcal{N}$: $\beta_t^{NS} > 0, \beta_t^{NN} < 0$, for $t > 2005$. To express the competitive effect in a concrete manner, we increase the two competition indices by one standard deviation.[28] For instance,

$$\tau_t^{SN} = \frac{\hat{\beta}_t^{SN} \text{ Std.dev.} \left(\text{comp}^N \,|\, \mathcal{S}\right)}{\hat{\alpha}} \tag{27}$$

measures the effect of increased exposure to competition from other hospitals in $\mathcal{N}$ on the response of a hospital subject to the reform. Coefficients τ_t^{SS}, τ_t^{NS}, and τ_t^{NN} are similarly defined. Standard errors for these parameters are estimated by bootstrap as explained above. Table 15 shows that the complementarity between the payment reform and competitive forces is strong. For instance, for an hospital subject to the reform, increasing exposure to competition from hospitals subject to the reform by one standard deviation increases the response by 1.3 minute, that is, by almost three fourth of the average relative effect given above. Similarly, increasing exposure to competition from hospitals *not* subject to the reform by one standard deviation decreases the response by 1.5 minute. Moreover, the order of magnitude of each of the two competitive effects is twice higher when the concerned hospital is a for-profit provider (1.3 and 2.5 on the one hand, -1.5 and -2.7 on the other hand), namely the average relative effect plus 50%.

Marginal utility of income A third prediction from theory is that among hospitals in $\mathcal{S}$, attractiveness increases more rapidly for hospitals with high marginal utility of income: $\beta_t^{SF} > 0$. To measure this effect in terms of extra travel time that patients are ready to incur, we compute

$$\tau_t^{SF} = \frac{\hat{\beta}_t^{SF} \text{ Std dev.} \left(\text{debt ratio} \,|\, \mathcal{S}\right)}{\hat{\alpha}}.$$

For an hospital subject to the reform, increasing the debt ratio by one standard deviation increases the response by .4 minute, about 20% of the average relative effect of the reform.

[28]The standard deviations of the two indices within each subgroups $\mathcal{N}$ and $\mathcal{S}$ are found in Table 1. For instance the standard deviation in (27) is .702.

8 Concluding remarks

Between 2005 and 2008, the rule applied to nonprofit French hospitals has shifted from global budgeting to prospective payment, while for-profit clinics have experienced no major regulatory change. By estimating a structural model of hospital choice based on all surgery admissions over this period, we have documented the complementarity between stronger reimbursement incentives and nonprice competition in the hospital industry.

Although we have confined ourselves to a positive analysis,[29] our findings shed light on the policy debate around the role of competition in this industry. Public discussions in France tend to focus exclusively on the competition between public (nonprofit) hospitals and private (for-profit) clinics, with the sharing of the aggregate revenue between the public and private sectors being a politically sensitive matter. Our empirical results demonstrate the equally important role of intra-sector competition.

First, we have shown that government-owned and other nonprofit hospitals, when properly stimulated by financial incentives, have been able to take market shares away from private clinics. Second, we have put forward the role of inter-sector competition in propagating incentives across hospitals: private clinics exposed to competition from public hospitals have responded to the reform although they were not directly concerned. Third, and most importantly, we have shown that intra-sector competition plays an important role as well: competition between nonprofit hospitals has exacerbated the incentive effects created by the reform, while competition between for-profit clinics has insulated them from the policy change. These results are consistent with the prediction from theory.

On the practical side, it is important for regulators to be aware of competitive effects when conducting policy reforms that change hospital incentives. Indeed the shifts in patient flows may affect the revenues earned by hospitals and jeopardize their financial viability, which may require transitory measures. Moreover, these shifts have a potentially important impact on overall public hospital spending when reimbursement rates differ across hospitals. As explained in Section 4.5, governments therefore should correctly anticipate the effect of competition when changing reimbursement incentives.

A natural extension of this study is to link the shifts in patient flows to actions

[29] Our approach does not allow to carry out welfare computations. The shifts in patient flows indeed identify only the changes in *relative* attractiveness, i.e., in the differences of attractiveness between hospitals.

taken by the hospitals. To increase their relative attractiveness and gain market shares, they may change technological processes,[30] invest in equipment and human resources, carry out managerial and organizational innovations, etc. In the process, certain dimensions of care quality, such as patient health outcomes or waiting times for elective procedures, may evolve differently across hospitals, which may be observed by patients or refereeing physicians –e.g., via rankings in newspapers or professional journals. All these variables are determined or at least influenced by hospitals, and hence should be modeled jointly with hospital choice by patients, a task that we leave for future research.

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[30] An example of particular interest is the development of outpatient care.

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Tables

Table 7: Specification with an outside option

Travel time	-0.025***	-0.025***
	(0.000)	(0.000)
S × 2006	0.023**	
	(0.008)	
S × 2007	0.053***	
	(0.009)	
S × 2008	0.066***	
	(0.010)	
Pri-owned × 2006		0.047**
		(0.014)
Pri-owned × 2007		0.072***
		(0.016)
Pri-owned × 2008		0.104***
		(0.017)
Gov-owned × 2006		0.021
		(0.012)
Gov-owned × 2007		0.057***
		(0.013)
Gov-owned × 2008		0.046**
		(0.014)
Gov-owned × debt ratio 2005 × 2006		-0.016
		(0.022)
Gov-owned × debt ratio 2005 × 2007		-0.026
		(0.025)
Gov-owned × debt ratio 2005 × 2008		0.025
		(0.025)
S × comp^S × 2006	0.118**	0.056
	(0.037)	(0.050)
S × comp^S × 2007	0.150***	0.164**
	(0.039)	(0.052)
S × comp^S × 2008	0.212***	0.146**
	(0.042)	(0.056)
N × comp^S × 2006	0.097**	0.054
	(0.033)	(0.034)
N × comp^S × 2007	0.183***	0.160***
	(0.038)	(0.040)
N × comp^S × 2008	0.184***	0.139**
	(0.043)	(0.046)
S × comp^N × 2006	-0.079**	0.005
	(0.027)	(0.019)
S × comp^N × 2007	-0.102***	-0.018
	(0.029)	(0.020)
S × comp^N × 2008	-0.119***	-0.007
	(0.031)	(0.023)
N × comp^N × 2006	-0.053*	0.004
	(0.023)	(0.014)
N × comp^N × 2007	-0.105***	-0.021
	(0.028)	(0.017)
N × comp^N × 2008	-0.081**	0.009
	(0.031)	(0.021)
S ×UC_{04}× 2006	0.123***	0.104***
	(0.031)	(0.031)
S ×UC_{04}× 2007	0.075*	0.044
	(0.035)	(0.037)
S ×UC_{04}× 2008	0.079*	0.077*
	(0.032)	(0.033)
N ×UC_{04}× 2006	-0.160	-0.160
	(0.135)	(0.138)
N ×UC_{04}× 2007	0.022	0.027
	(0.149)	(0.151)
N ×UC_{04}× 2008	0.005	0.003
	(0.173)	(0.177)
Observations	2852783	2627296
R^2	0.275	0.281

Source. French PMSI, individual data, 2005-2008.
Sample. 1,153 hospitals in mainland France.
Note. A market is defined as the set of hospitals within 60' travel time.
Robust standard errors in parentheses.
Controls include density, income, population of h's *département*.

Table 8: Travel costs

	(1) (OLS)	(2) (OLS)	(3) (OLS)
Travel time	-0.040***	-0.040***	-0.042***
	(0.000)	(0.000)	(0.000)
# of pairs $(h, h^{\text{ref}}(z))$	13035	13036	13007
Average # of zipcodes per pair	18.5	18.5	18.3
Observations	2758304	2650617	2319871
R^2	0.320	0.325	0.325

Source. French PMSI, individual data, 2005-2008.

Sample. 1,153 hospitals in mainland France.

Note. Reference hospital:

(1) the largest in the *département*

(2) the largest nonprofit in the *département*

(3) the largest for-profit in the *département*

Robust standard errors in parentheses.

Table 9: Travel costs, dropping pairs of hospitals with small number of zipcodes

Threshold	1	10	20	50	100
Travel time	-0.040***	-0.040***	-0.041***	-0.040***	-0.040***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2758304	2484893	2249367	1758495	1201759
R^2	0.320	0.321	0.320	0.307	0.266

Source. French PMSI, individual data, 2005-2008.

Sample. 1,153 hospitals in mainland France.

Note. Reference hospital: the largest in the *département*

Robust standard errors in parentheses.

Pairs $(h, h^{\text{ref}}(z))$ with at least [threshold] zipcodes.

Table 10: Estimation of the impact of competition

	(1)	(2)	(3)
S × 2006	-0.002	0.003	0.026***
	(0.005)	(0.005)	(0.006)
S × 2007	0.031***	0.035***	0.068***
	(0.005)	(0.006)	(0.006)
S × 2008	0.076***	0.076***	0.073***
	(0.006)	(0.006)	(0.007)
S × comp^S × 2006	0.270***	0.272***	0.198***
	(0.024)	(0.025)	(0.021)
S × comp^S × 2007	0.250***	0.276***	0.192***
	(0.025)	(0.026)	(0.022)
S × comp^S × 2008	0.202***	0.271***	0.226***
	(0.026)	(0.027)	(0.023)
N × comp^S × 2006	0.310***	0.274***	0.124***
	(0.023)	(0.023)	(0.034)
N × comp^S × 2007	0.198***	0.197***	0.096**
	(0.024)	(0.024)	(0.036)
N × comp^S × 2008	0.339***	0.370***	0.265***
	(0.025)	(0.025)	(0.038)
S × comp^N × 2006	-0.091***	-0.104***	-0.105***
	(0.019)	(0.019)	(0.018)
S × comp^N × 2007	-0.148***	-0.166***	-0.125***
	(0.020)	(0.020)	(0.020)
S × comp^N × 2008	-0.156***	-0.194***	-0.139***
	(0.021)	(0.021)	(0.021)
N × comp^N × 2006	-0.154***	-0.154***	-0.053
	(0.019)	(0.019)	(0.027)
N × comp^N × 2007	-0.096***	-0.109***	-0.068*
	(0.019)	(0.020)	(0.029)
N × comp^N × 2008	-0.257***	-0.277***	-0.155***
	(0.020)	(0.020)	(0.030)
S ×UC_{04}× 2006	0.143***	0.148***	0.095**
	(0.015)	(0.015)	(0.033)
S ×UC_{04}× 2007	0.088***	0.094***	0.029
	(0.016)	(0.016)	(0.034)
S ×UC_{04}× 2008	0.183***	0.206***	0.117***
	(0.016)	(0.016)	(0.035)
N ×UC_{04}× 2006	-0.743***	-0.426***	-0.237***
	(0.084)	(0.100)	(0.072)
N ×UC_{04}× 2007	-0.462***	-0.267**	0.133
	(0.087)	(0.103)	(0.076)
N ×UC_{04}× 2008	-0.239**	-0.101	-0.008
	(0.091)	(0.107)	(0.082)
Hospital-year controls	Yes	Yes	Yes
Observations	1786346	1710208	1504927
R^2	0.005	0.003	0.005

Source. French PMSI, individual data, 2005-2008.
Sample. 1,153 hospitals in mainland France.
Note. Reference hospital:
(1) the largest in the *département*
(2) the largest public in the *département*
(3) the largest private in the *département*
Robust standard errors in parentheses.
Controls include density, income, population of h's *département*.

Table 11: Average relative effects in 2008 (in minutes), by reference hospital

Reference hospital	(1)	(2)	(3)
Average relative effect in 2006 (minutes)	0.442	0.472	0.720
Average relative effect in 2007 (minutes)	0.813	0.853	1.484
Average relative effect in 2008 (minutes)	1.846	1.786	1.438

Source. French PMSI, individual data, 2005-2008.

Sample. 1,153 hospitals in mainland France.

Note. Reference hospital:

(1) the largest in the *département*

(2) the largest public in the *département*

(3) the largest private in the *département*

Table 12: Average relative effects in 2008 (in minutes), dropping small demand units gzt

Min number of patients in gzt	1	2	5	10	20	50	100
Average relative effect (minutes)	1.846	1.579	1.539	1.461	1.239	0.920	0.636

Source. French PMSI, individual data, 2005-2008.

Sample. 1,153 hospitals in mainland France.

Note. Reference hospital: the largest in the *département*

Table 13: Average relative effect in 2008 (in minutes), by clinical department

	Activity share (1)	Average relative effect in 2008 (Mean) (2)	S.E. (3)	Median time (4)	Ratio (%) (2)/(4)
Orthopedics	27.1%	0.522**	(0.227)	22.5	2.3
ENT, Stomato.	13.0%	3.242***	(0.344)	20.5	15.8
Ophthalmology	12.7%	2.387***	(0.514)	23.5	10.2
Gastroenterology	11.8%	1.909***	(0.289)	18.5	10.3
Gynaecology	8.5%	3.011***	(0.398)	23	13.1
Dermatology	7.2%	4.116***	(0.472)	20	20.6
Nephrology	7.0%	2.015***	(0.497)	21	9.6
Circulatory syst.	5.1%	4.847***	(0.636)	24	20.2
Nervous system	2.4%	−7.350***	(1.624)	24	-30.6
Cardiology	1.7%	1.118	(1.627)	30	3.7
All	100.0%	1.846***	(0.128)	22	8.4

Source. French PMSI, individual data, 2005-2008.

Sample. 1,153 hospitals in mainland France.

Note. Reference hospital: the largest in the *département*

Standard errors are computed by bootstrap.

Controls include density, income, population of h's *département*.

Table 14: Allowing for heterogeneous marginal utilities of income

Pri-owned × 2006	0.079***
	(0.010)
Pri-owned × 2007	0.054***
	(0.010)
Pri-owned × 2008	0.041***
	(0.010)
Gov-owned × 2006	-0.066***
	(0.011)
Gov-owned × 2007	-0.019
	(0.011)
Gov-owned × 2008	-0.001
	(0.011)
Gov-owned × debt ratio 2005 × 2006	-0.028*
	(0.013)
Gov-owned × debt ratio 2005 × 2007	0.020
	(0.014)
Gov-owned × debt ratio 2005 × 2008	0.093***
	(0.014)
S × comp^S × 2006	0.246***
	(0.028)
S × comp^S × 2007	0.363***
	(0.029)
S × comp^S × 2008	0.328***
	(0.030)
N × comp^S × 2006	0.416***
	(0.040)
N × comp^S × 2007	0.407***
	(0.041)
N × comp^S × 2008	0.572***
	(0.043)
S × comp^N × 2006	-0.054***
	(0.014)
S × comp^N × 2007	-0.134***
	(0.015)
S × comp^N × 2008	-0.094***
	(0.017)
N × comp^N × 2006	-0.121***
	(0.015)
N × comp^N × 2007	-0.091***
	(0.016)
N × comp^N × 2008	-0.102***
	(0.017)
S ×UC$_{04}$× 2006	0.083***
	(0.017)
S ×UC$_{04}$× 2007	0.060***
	(0.018)
S ×UC$_{04}$× 2008	0.150***
	(0.018)
N ×UC$_{04}$× 2006	-0.338***
	(0.102)
N ×UC$_{04}$× 2007	-0.181
	(0.105)
N ×UC$_{04}$× 2008	0.080
	(0.110)
Hospital-year controls	Yes
Observations	1585710
R^2	0.003

Source. French PMSI, individual data, 2005-2008.
Sample. 1,153 hospitals in mainland France.
Note. Reference hospital: the largest nonprofit in the *département*.
Robust standard errors in parentheses.
Controls include density, income, population of h's *département*.

Table 15: Effect of competition in 2008 (in minutes)

Competition	SS	NS	SN	NN
Effect of one s.d. of comp. index	1.348	2.466	-1.482	-2.718
Standard error	(0.178)	(0.175)	(0.208)	(0.215)

Note. Increasing the exposure index by one standard deviation

Source. French PMSI, individual data, 2005-2008.

Sample. 1,153 hospitals in mainland France.

Note. Reference hospital: the largest in the *département*

Standard errors are computed by bootstrap.

Table 16: Effect of marginal utility of income in 2008 (in minutes)

Effect of one s.d. of debt ratio	0.377
Standard error	(0.056)

Note. Increasing the debt ratio by one standard deviation

Source. French PMSI, individual data, 2005-2008.

Sample. 1,153 hospitals in mainland France.

Note. Reference hospital: the largest in the *département*

Standard errors are computed by bootstrap.

A Comparative statics in the linear model

In the linear model, the hospital objective function is

$$V^h = [\lambda_h r_h - \lambda_h c_{0h} + \lambda_h e + v_h + (a_h - \lambda_h c_h)u]\, s - \frac{b_h}{2}u^2 - \frac{w_h}{2}e^2 + \lambda_h(\bar{R}_h - F_h),$$

which yields (10) by differentiating with respect to u. We assume that the patients are uniformly distributed on the Salop circle and normalize the length of that circle (and hence the patient density) to one. The demand addressed to hospital h is given by

$$s^h(u_h, u_l, u_r) = \frac{d_{hl} + d_{hr}}{2} + \frac{u_h}{\alpha} - \frac{u_l + u_r}{2\alpha},$$

where u_l and u_r denote the utilities offered by the left and right neighbors and d_{hl} and d_{hr} are the distances between h and those neighbors. It follows that have $\partial s^h/\partial u_h = 1/\alpha$ and $\partial s^h/\partial u_{-h} = -1/(2\alpha)$.

Reaction function Differentiating (10) yields

$$\frac{\partial \mu^h}{\partial u_h} = \frac{2}{\alpha}(a_h - \lambda_h c_h) - b_h + \frac{\lambda_h}{\alpha}\frac{\partial e^h}{\partial u_h} \quad \text{and} \quad \frac{\partial \mu^h}{\partial u_{-h}} = -\frac{1}{2\alpha}(a_h - \lambda_h c_h) + \frac{\lambda_h}{\alpha}\frac{\partial e^h}{\partial u_{-h}}.$$

Differentiating the cost-containment effort $e^h(u_h, u_{-h}) = \lambda_h s^h/w_h$, we find $\partial e^h/\partial u_h = \lambda_h/(\alpha w_h)$ and $\partial e^h/\partial u_{-h} = -\lambda_h/(2\alpha w_h)$, and get the slope of the reaction function $\rho_h = -\left(\partial \mu^h/\partial u_{-h}\right) / \left(\partial \mu^h/\partial u_h\right)$. As the derivative $\partial \mu^h/\partial u_h = \partial^2 V^h/\partial u_h^2$ is negative by the second-order condition of the hospital problem, the sign of ρ_h is given by the sign of $(\lambda_h c_h - a_h)/\alpha - \lambda_h^2/(w_h \alpha^2)$ as indicated in Section 4.2.

Role of cost parameters We now check that ρ_h increases with c_h or equivalently in $\lambda_h c_h$ at given λ_h. We first recall that the denominator of (12) is positive and we observe that the ratio $(x + x_1)/(x + x_0)$ increases with x at the right of its vertical asymptote, i.e., in the region $(-x_0, \infty)$, if and only if $x_0 > x_1$. This yields the desired results with $x_0 = -a_h + \alpha b_h/2 - \lambda_h^2/(2\alpha w_h)$ and $x_1 = -a_h - \lambda_h^2/(\alpha w_h)$.

We now adapt the argument to check that ρ_h increases with w_h or equivalently with $z_h = -\lambda_h^2/(\alpha w_h)$ at given λ_h and α. We use $x_0 = 2(\lambda_h c_h - a_h) + \alpha b_h$ and $x_1 = \lambda_h c_h - a_h$. We have $x_0 > x_1$ in particular when the pecuniary cost dominates the altruism force, $\lambda_h c_h - a_h \geq 0$. In the opposite case, $\lambda_h c_h - a_h < 0$, we have $\rho_h < 0$ since the numerator in (12) is then negative. It follows that ρ_h is below its horizontal asymptote, $\rho_h < 1/2$, and since we are at the right of its vertical asymptote, ρ_h must increase in z_h, and hence in w_h.

Average relative effect When the coefficients $a_h, b_h, c_h, \lambda_h, w_h$ are constant across hospitals, the reaction functions of all hospitals have the same slope, and the Jacobian matrix of the incentives has the following structure

$$F = \begin{bmatrix} 1 & -\rho & 0 & -\rho \\ -\rho & 1 & -\rho & 0 \\ 0 & -\rho & 1 & -\rho \\ -\rho & 0 & -\rho & 1 \end{bmatrix} \tag{A.1}$$

In the absence of the cost-containment term, the absolute value of the slope, $|\rho|$, is strictly lower than 1/4. We assume that it remains below 1/2 in the presence of that term, which yields strict diagonal dominance and hence invertibility for F. The matrix F is symmetric and circulant.[31] The inverse matrix $T = F^{-1}$, therefore, is circulant, too, and we can denote the transmission coefficients as $t_{hk} = t(k-h)$ where $j-i$ is modulo 4; for instance $t(3) = t(-1)$. Furthermore $t(k-h) = t(h-k)$ because T is symmetric. The transmission coefficients are given by

$$[t(0),\, t(1),\, t(2),\, t(3)] = \left(\frac{1-2\rho^2}{1-4\rho^2}, \frac{\rho}{1-4\rho^2}, \frac{2\rho^2}{1-4\rho^2}, \frac{\rho}{1-4\rho^2}\right). \tag{A.2}$$

As announced in the text, we check that $t(0) + t(2) > 2t(1)$ if $\rho > 0$ and $t(0), t(2) > 0 > t(1)$ if $\rho < 0$, which yields (14).

Unused capacities of hospitals in $\mathcal{N}$ We consider the situation represented on Figure 2(b) with three symmetric hospital in $\mathcal{S}$ and one hospital in $\mathcal{N}$. Denoting by ρ_S the common slope of reaction functions of S_1, S_2 and $S_{2'}$ and ρ_S that of N_3, and numbering the hospitals according to $\{S_1, S_2, N, S_{2'}\} = \{1, 2, 3, 4\}$, we find that the matrix defined by (5) is given here by

$$F = \begin{bmatrix} 1 & -\rho_S & 0 & -\rho_S \\ -\rho_S & 1 & -\rho_S & 0 \\ 0 & -\rho_N & 1 & -\rho_N \\ -\rho_S & 0 & -\rho_S & 1 \end{bmatrix}. \tag{A.3}$$

[31] A circulant matrix is one for which each row vector is rotated one element to the right relative to the preceding row vector.

Computing $T = F^{-1}$ and using $\mathrm{d}u_i = [t_{i1} + t_{i2} + t_{i4}]\, \Delta \mathrm{d}r$, we check that

$$\mathrm{d}u_{S_1} - \mathrm{d}u_{S_2} = \frac{\rho_S - 2\rho_S\rho_N}{1 - 2\rho_S^2 - 2\rho_S\rho_N}\Delta \mathrm{d}r.$$

It is easy to check that $\mathrm{d}u_{S_1} - \mathrm{d}u_{S_2}$ decreases (increases) with ρ_N if $\rho_S > 0$ ($\rho_S < 0$). According to Remark 1, we know that N's unused capacity is associated with a lower slope of its reaction function, ρ_N, hence the results announced in the text.

To study the impact of unused capacities of hospitals in $\mathcal{N}$ on the responses of hospitals also in $\mathcal{N}$, we consider the configuration shown on Figure 4 with four private clinics not subject to the reform and a nonprofit hospital located at the center of the circle. The patients are uniformly distributed over the set consisting of the circle and the four radiuses (SN_i). We normalize the total length of this set (and hence the patient density) to one. The market share of a hospital depends on the utility supplied by that hospital and by those supplied by its *three* adjacent neighbors, with $\partial s^h/\partial u_h = 3/(2\alpha)$ and $\partial s^h/\partial u_k$ equal to $-1/(2\alpha)$ if k is an adjacent neighbor of h, and to zero otherwise. The derivative of ρ^h with respect to u_k is the same for all three adjacent neighbors k of hospital h and is called hereafter the slope of the reaction function.

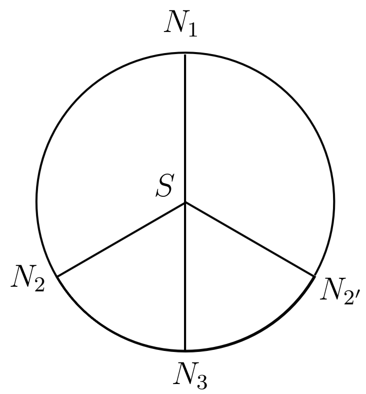

Figure 4: A market configuration with five hospitals

We assume that N_1, N_2 and $N_{2'}$ have the same cost and preference parameters and denote by ρ_N the common slope of their reaction function. These three nonprofit hospitals are symmetric in every way but their proximity to N_3. We are interested in the effect of N_3's unused capacity on the double difference $\mathrm{d}u_{N_1} - \mathrm{d}u_{N_2}$. We denote by ρ_3 and ρ_S the slope of the reaction function of N_3 and S respectively. Numbering the hospitals as $\{N_1, N_2, N_3, N_{2'}, S\} = \{1, 2, 3, 4, 5\}$, we find that the matrix defined by (5) is given here by

$$F = \begin{bmatrix} 1 & -\rho_N & 0 & -\rho_N & -\rho_N \\ -\rho_N & 1 & -\rho_N & 0 & -\rho_N \\ 0 & -\rho_3 & 1 & -\rho_3 & -\rho_3 \\ -\rho_N & 0 & -\rho_N & 1 & -\rho_N \\ -\rho_S & -\rho_S & -\rho_S & -\rho_S & 1 \end{bmatrix}. \tag{A.4}$$

Computing $T = F^{-1}$ and using $\mathrm{d}u_i = t_{i5}\Delta\mathrm{d}r$, we check that $\mathrm{d}u_{N_2} - \mathrm{d}u_{N_1}$, $\mathrm{d}u_{N_3} - \mathrm{d}u_{N_1}$ and $\mathrm{d}u_{N_3} - \mathrm{d}u_{N_2}$ increases (decreases) with ρ_3 if $\rho_N > 0$ ($\rho_N < 0$). It follows that under strategic complementarity larger amounts of unused capacities at clinic N_3 are associated with a weaker response of N_2 relative to that of N_1, as reported in cell B2 of Table 3, and with a weaker response of N3 relative to that of both N_1 and N_2, as reported in cell A2 of Table 3. The result is reversed under strategic substitutability (cells A4 and B4).

Unused capacities of hospitals in $\mathcal{S}$ We consider the situation represented on Figure 2(c) with three symmetric hospital in $\mathcal{N}$ and one hospital in $\mathcal{S}$, which we label as follows: $\{N_1, N_2, S, N_{2'}\} = \{1, 2, 3, 4\}$. The matrix F is obtained from (A.3) by switching ρ_N and ρ_S. Computing $T = F^{-1}$ and using $\mathrm{d}u_i = t_{i3}\Delta\mathrm{d}r$, we check that

$$\mathrm{d}u_{N_2} - \mathrm{d}u_{N_1} = \frac{\rho_N - 2\rho_N^2}{1 - 2\rho_N^2 - 2\rho_N\rho_S}\Delta\mathrm{d}r.$$

The amount of unused capacity of hospital S has a negative impact on ρ_S and a positive one on the direct effect $\Delta\mathrm{d}r$, both of which affecting $\mathrm{d}u_{N_2} - \mathrm{d}u_{N_1}$. If $\rho_N < 0$, $\mathrm{d}u_{N_2} - \mathrm{d}u_{N_1}$ unambiguously decreases with S's unused capacity. If $\rho_N > 0$, the same monotonicity properties hold if we assume that in the comparative statics analysis the change in the direct effect Δ dominates the change in the slope ρ_S.

We now consider the case with four hospitals subject to reform, Figure 2(d), three of them being symmetric, S_1, S_2 and $S_{2'}$ and the last one being denoted by S_3. We call ρ_S and ρ_3 the slopes of corresponding reaction functions. The matrix F is obtained from (A.3) by replacing ρ_N with ρ_3. Denoting by Δ_S and Δ_3 the direct effects, we have $\mathrm{d}u_i = [t_{i1} + t_{i2} + t_{i4}]\,\Delta_S\mathrm{d}r + t_{i3}\Delta_3\mathrm{d}r$. The unused capacity of hospital S_3 affects both ρ_3 and Δ_3. The double difference $\mathrm{d}u_{S_2} - \mathrm{d}u_{S_1}$, is linear in $\Delta_3\mathrm{d}r$, with the contribution of Δ_3 being

$$\frac{\rho_S(1 - 2\rho_S)}{1 - 2\rho_S^2 - 2\rho_S\rho_3}\Delta_3\mathrm{d}r.$$

This double difference therefore increases (decreases) with Δ_3 if $\rho_S > 0$ ($\rho_S < 0$), hence the results reported in cells C1 and C3 of Table 3. It is easy to check that the differences $\mathrm{d}u_{S_3} - \mathrm{d}u_{S_1}$ and $\mathrm{d}u_{S_3} - \mathrm{d}u_{S_2}$ is linearly increasing in Δ_3, with slope $(1-2\rho_S)(1+\rho_S)/(1-2\rho_S^2-2\rho_S\rho_3) > 0$, hence the results reported in cells A1 and A3 of the table.

Budget-neutral reform For clarity, we omit here the cost-containment effort and consider a simpler objective of the form $V^h(\pi, s, u)$. Differentiating with respect to u_h yields hospital h's marginal incentive to increase gross utility:

$$\mu^h(u_h, u_{-h}; r_h, \bar{R}_h) = V_\pi^h \left\{[r_h - (c_{0h} + c_h u_h)]s_h^h - c_h s^h\right\} + V_s^h s_h^h + V_u^h,$$

where a subscript indicates partial differentiation. The hospital revenue enters the (possibly endogenous) marginal utility of revenue, $\lambda_h = V_\pi^h$, as well as possibly the partial derivatives V_N^h and V_u^h. Concentrating on the first term of the above sum, we observe that $r_h V_\pi^h s_h^h$ increases in r_h if V_π^h is fixed. Yet a rise in r_h may increase the hospital revenue, thus lowering V_π^h if the marginal utility of income is decreasing. Such an income effect makes the sign of $\partial\mu^h/\partial r_h$ *a priori* ambiguous.

Differentiating the first-order conditions $\mu^h = 0$ with respect to r_h while keeping the hospital revenues fixed yields

$$\mathrm{D}_u\mu.\mathrm{d}u + \Delta\,\mathrm{d}r = 0, \tag{A.5}$$

where Δ is the diagonal matrix with $\lambda_h s_h^h$ on its diagonal. To keep hospital revenues fixed, the government must change the lump-sum transfers by $\mathrm{d}\bar{R}_h = -s^h\mathrm{d}r_h - r_h\mathrm{d}s^h$, where $\mathrm{d}s^h = \mathrm{d}_u s^h.\mathrm{d}u$ and $\mathrm{d}u$ is solution to (A.5).

To maintain the hospital revenues unchanged, however, the government needs to know all the parameters of the problem so as to anticipate the post-reform equilibrium. In theory, though, changing the policy rule from $(\bar{R}_h, r_h)$ to $(\bar{R}_h + \mathrm{d}\bar{R}_h, r_h + \mathrm{d}r_h)$ increases reimbursement incentives while neutralizing income effects.