Hospital financial incentives
and nonprice competition*

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Abstract

To assess the nature and strength of strategic interactions in the hospital industry, we model patient flows over the phase-in period of a policy reform that gradually increased reimbursement incentives. Rather than relying on clinical quality indicators, we infer changes in the gross utilities provided by hospitals from the evolution of local market shares. In the light of comparative statics predictions for oligopoly under nonprice competition, our econometric results suggest that the utilities supplied to patients are strategic complements. Overall, we document a strong complementarity between reimbursement incentives and nonprice competition.

JEL Codes: D43; H51; I11; I18; L13.

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1 Introduction

In many advanced countries, payment system reforms 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 for this purpose often use 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.

In the present article, we model the evolution of patient flows as hospital reimbursement incentives become stronger. Our ultimate goal is to assess the nature and strength of strategic interactions in the hospital industry. Whether the utilities provided by hospitals are strategic complements or strategic substitutes is of particular interest to us because it affects the way policy changes are transmitted to the hospital industry and ultimately to patients.

To address this question and inform the design of hospital incentives, we take advantage of a policy reform that has taken place in France over the years 2005 to 2008. The incentives placed on government-owned and other nonprofit hospitals have gradually been 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; those clinics, 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. On the theory side, we build a nonprice competition model where hospitals compete in utility to attract patients, and describe economic forces that tend to make utilities strategic complements or strategic substitutes. Unlike previous research (e.g., Pope (1989), Ellis (1998), Brekke, Siciliani, and Straume (2011)), we focus 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.

A first lesson from the theoretical analysis is 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. The main issue, however, is how equilibrium responses depend on the proximity of neighboring hospitals and on the amounts of capacity that are unused at those hospitals. Two considerations are relevant: (i) whether each neighbor is itself subject to the reform; (ii) whether the utilities supplied to patients are strategic complements or strategic substitutes. Under strategic complementarity, we find that the proximity and unused capacities of hospitals (not) subject to the reform magnify (attenuate) the response to the reform. The effects are reversed under strategic substitutability. We also predict that among hospitals subject to the reform those with a higher marginal utility of income should 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 these changes from the observed patient flows at a detailed geographic level. 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.

Placing an adequate structure on utility variations, we determine how hospitals’ responses to higher reimbursement rates depend on their own characteristics and on their competitive environment. Specifically, we construct indicators that measure how any given hospital is exposed to competition from hospitals that are respectively subject and not subject to the reform. Following the theoretical analysis, we base these indicators on distances to, and unused capacities of, other hospitals. (To avoid endogeneity problems, we compute the indicators before the start of the period of interest.)

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% of the median travel time. Patients are ready to travel two minutes more after the reform to seek treatment from a hospital that has been subject to the reform. In other words, the catchment areas of those hospitals have increased on average by 2 minutes relative to those of other hospitals.

Our main findings, however, are about the effect of competition. They strongly suggest that the utilities supplied to patients are strategic complements. A one-standard-deviation increase in exposure to competition from hospitals subject to the reform raises hospital responses by about 2 minutes, an order of magnitude similar to that of the average relative effect. Similarly, a one-standard-deviation increase in exposure to competition from hospitals not subject to the reform lowers responses by about 2 minutes. These effects are about one and a half times stronger when the concerned hospital is itself subject to the reform. We are thus able to assess the strength of competitive interactions not only between the for-profit and nonprofit sectors, but also within each of them. Overall, we find a quite strong complementarity between competition forces and the change in payment incentives.

Finally, we use hospitals’ debt ratios at the start of the reform as proxies for their marginal utility of income. Indeed, more indebted hospitals presumably are in greater need of extra revenues. As predicted by theory, we find that these hospitals have reacted more vigorously to the reform. A one-standard-deviation increase in debt ratio raises the response by about .4 minute.

The paper is organized as follows. Section 2 connects our work to previous literature. Section 3 provides industry background, describes the policy reform, and offers some 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). For instance, Gaynor, Propper, and Seiler (2012) investigate how hospital quality has been affected by a policy reform that increased patient choice in the United Kingdom, and for this purpose construct a measure of hospital mortality that is corrected for patient selection. In a different vein, Gravelle, Santos, and Siciliani (2014) es-
estimate a linear spatial lag model on cross-sectional data to examine how hospital quality is affected by the quality provided by neighboring hospitals.\footnote{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.} 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 may involve many parties (medical staff, relatives) along with the concerned patient. 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 on assumptions about how long patients consider traveling to visit a hospital, and then check for the robustness of their findings to the chosen 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 diagnoses or medical procedures,\footnote{Tay (2003), Gaynor, Propper, and Seiler (2012), Ho and Pakes (2014) consider respectively heart attack, coronary artery bypass graft, birth deliveries.} we aggregate the data at the level of clinical departments, e.g., orthopedics, stomatology, etc. We estimate the extent to which each hospital has become more attractive—in relative terms—following the policy reform in each of these departments. At this level of aggregation, the upcoding incentives documented by Dafny (2005) are 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 was taken by the local governments that own them. The logic at work in
the present study is strikingly different as the reform at stake has unambiguously given public hospitals stronger 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. 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 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 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 3. 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 in 2008), 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

\[^3\text{In 2010, 96\% of French households were covered by supplementary health insurance.}\]
stages. The policy reform considered in this article applied to the set, hereafter denoted by \( \mathcal{S} \), of all nonprofit hospitals, either government-owned or private. Before March 2004, nonprofit 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.\(^4\)

We now describe the rules in force for the set of all private, for-profit clinics, which we denote by \( \mathcal{N} \). (The sets \( \mathcal{N} \) and \( \mathcal{S} \) are therefore complementary in the universe of all hospitals, see Table 3.) Before 2005, for-profit clinics were indeed 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.\(^5\)

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. 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 3, it is easy to check that hospitals in \( \mathcal{S} \) accounted for 39.8% (41.9%) of all surgery admissions in 2005 (2008). Figure 4 shows that the number of admissions in hospitals subject to the reform increased over the period while the admissions in for-profit clinics slightly decreases. The differential increase (double difference) amounted to 197,000 stays.

\(^4\)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.

\(^5\)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.
Table 4 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.

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:

\[ U_{ih} = u_h + \zeta_{ih}. \]  

(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 \( \zeta_{ih} \) 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. Integrating over the disturbances \( \zeta_{ih} \), 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 either market shares or 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:

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

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 for all hospitals $\partial \mu^h / \partial u_h < 0$.

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 $D_{u\mu}$ 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.\footnote{The role of the lump-sum transfers is discussed in Section 4.5.} 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

$$\frac{\partial \mu^h}{\partial u_h} du_h + \frac{\partial \mu^h}{\partial u_{-h}} du_{-h} + \frac{\partial \mu^h}{\partial r_h} dr_h = 0. \quad (3)$$

We define the direct effect $\Delta_h$ 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:

$$\Delta_h dr_h = \frac{\partial u_h}{\partial r_h |_{u_{-h}=0}} dr_h = -\frac{\partial \mu^h / \partial r_h}{\partial \mu^h / \partial u_h} dr_h. \quad (4)$$
We denote by $\Delta$ the diagonal matrix with $\Delta_h$ on its diagonal. The vector $\Delta dr$ 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 $\rho^h$ in the direction $k$, i.e.

$$F_{hk} = -\frac{\partial \rho^h}{\partial u_k |_{dr=0}} = \frac{\partial \mu^h_k}{\partial u_k} / \frac{\partial \mu^h}{\partial u_k}.$$  \hfill (5)

Setting $F_{hh} = 1$, we introduce the matrix $F$ with generic entry $F_{hk}$,\footnote{In a simple example with four hospitals, the matrix $F$ takes the form given by equation (A.1) in appendix.} as well as its inverse $T = F^{-1}$. Rearranging (3), we get

$$du = T \Delta dr.$$  \hfill (6)

The transmission matrix $T$ summarizes how the direct effects $\Delta dr$ 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 $S$, and are left unchanged for the other hospitals. The complementary set of $S$ is denoted by $N$. Although direct effects exist only for hospitals in $S$, the hospitals in $N$ are indirectly affected by the reform via the equilibrium effects embodied by the transmission matrix $T$. Formally, $dr_h > 0$ for hospitals subject to the reform ($h \in S$), and $dr_h = 0$ for hospitals not subject to the reform ($h \in N$). The changes in equilibrium utilities are given by

$$du_h = \sum_{k \in S} t_{hk} \Delta_k dr_k.$$  \hfill (7)

In the empirical part of the paper, we infer the utility changes $du_h$ 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 de-
tails 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 two issues in turn.

Regarding first the firms’ objectives, we assume that hospital decisions are driven by both financial and non-financial considerations, namely, revenue and monetary costs on the one hand, non-pecuniary costs and intrinsic motives on the other hand. Moreover, as in Brekke, Siciliani, and Straume (2012), we let hospitals choose a level of cost-containment effort $e$ on top of the gross utility $u$ they provide to patients. (Below we express $e$ as a function of $u$, which brings us back to the framework of Section 4.1.) We specify the objective function of hospital $h$ as

$$V^h(e,u) = \lambda_h \pi^h - \frac{b_h}{2} u^2 - \frac{wh}{2} e^2 + (v_h + a_h u) s^h,$$  \hspace{1cm} (8)

and now present the different ingredients of this function. The hospital profit function $\pi^h$ is the difference between revenues $\bar{R} + r_h s^h$ and total pecuniary costs. The cost function consists of a fixed part $F_h$ and a variable part $(c_{0h} - e + c_h u) s$:

$$C^h(s,u,e) = F_h + (c_{0h} - e + c_h u) s.$$ \hspace{1cm} (9)

The marginal pecuniary cost per admission, $c_{0h} - e + c_h u$, is constant and linearly increasing in the utility offered to patients. The second and third 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.\footnote{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.} 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 \( v_h \) of (8). The term \( a_h \) expresses the altruistic motive, whereby manager and staff enjoy providing high utility to patients.\(^9\)

When \( \lambda_h \) 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 \( \lambda_h \), the hospital manager puts a positive weight on financial performances. The limiting case of infinitely high \( \lambda_h \) 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 utility to increase the utility offered to patients is given by

\[
\mu^h(u_h, u_{-h}; r_h) = \left[ v_h - \lambda_h c_0 h + \lambda_h r_h + (a_h - \lambda_h c_h) u_h \right] \frac{\partial s^h}{\partial u_h} \\
+ (a_h - \lambda_h c_h) s^h - b_h u_h,
\]

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

Turning to the demand specification, 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 \( \alpha \) reflects the tradeoff between the average gross utility offered by a hospital and the distance between that hospital and the patient home.\(^{10}\) 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

\(^9\)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.

\(^{10}\)Multiplying all utilities \( u_h \) as well as the parameter \( \alpha \) 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.
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. We impose no restriction on the relative positions on the circle of the subsets $S$ and $N$: 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 $\mu^h$ are linear in $u_h$ and $u_{-h}$.

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

$$\Delta_h d_r = \frac{\lambda_h dr_h}{2(\lambda_h c_h - a_h) + \alpha b_h - \lambda^2_h/(\alpha w_h)}$$

(11)

for each hospitals subject to the reform, $h \in S$. 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 property is related to the absence of revenue effects in the linear model, which we discuss 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

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

(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 $(\lambda_h c_h - a_h)/\alpha - \lambda^2_h/(w_h \alpha^2) > 0$. As explained by Brekke, Siciliani, and Straume (2014), the gross utilities offered to patients can be either strategic complements ($\rho_h > 0$) or strategic substitutes ($\rho_h < 0$).

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

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\(11\) The following arguments only require that the market is covered and that hospitals are all active.
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 $\mu^h$ as $u_{-h}$ rises.\(^{12}\)

### 4.3 Market geography

In this section, we investigate how the proximity of hospitals in $S$ and in $N$ 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, $d r_h = d r > 0$ in $S$, we obtain that the direct effects given by (11) are the same for all hospitals subject to the reform, i.e., $\Delta_h d r_h = \Delta d r > 0$ for all $h$ in $S$. We then deduce from the fundamental equation (7) that $d u_h$ is proportional to the sum of the transmission coefficients, $\sum_{k \in S} t_{hk}$. 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).

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

$$\frac{1}{|S|} \sum_{h \in S} d u_h - \frac{1}{|N|} \sum_{k \in N} d u_k > 0, \quad (13)$$

where $|S|$ and $|N|$ denote the number of hospitals in $S$ and $N$. In the situation represented on Figure 1(a), we have $d u_S = d u_{S_h} = d u_{S_{-h}} = t(0) + t(2)$ and $d u_N = \ldots$\(^{13}\)

\(^{12}\)Formally, the fall in $\mu_h$ materializes in the term $\lambda_h e^h/\alpha = \lambda_h^2 s^h/(\alpha w_h)$ of equation (10) that decreases with $u_{-h}$.
Figure 1: Market configurations with four hospitals

\[ \text{du}_{N_2} = \text{du}_{N_2'} = 2t(1), \] so inequality (13) is equivalent to

\[ \text{du}_S - \text{du}_N = [t(0) + t(2) - 2t(1)] \Delta d_r > 0. \quad (14) \]

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). On the other hand, when the utilities are strategic substitutes, \( N_2 \) and \( N_2' \) respond to utility rises at hospitals \( S_1 \) and \( S_1' \) 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 1. 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,
Proximity of hospitals not subject to the reform  

Going beyond average relative effects, we now want to compare the relative effect of the reform within each of the two groups $S$ and $N$. We first investigate how the proximity of for-profit clinics in $N$ affects the response of nonprofit hospitals in $S$. To this aim, we consider the market configuration depicted on Figure 1(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 $d \nu_{S_1} = [t(0) + 2t(1)] \Delta d r$ and $d \nu_{S_2} = d \nu_{S_2'} = [t(0) + t(1) + t(2)] \Delta d r$, which yields the following difference in utility changes between the hospitals:

$$d \nu_{S_1} - d \nu_{S_2} = d \nu_{S_1} - d \nu_{S_2'} = [t(1) - t(2)] \Delta d r. \quad (15)$$

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 $d \nu_{S_1} - d \nu_{S_2}$ is positive: the proximity of the hospital in $N$ attenuates the effect of the reform. On the contrary, when the utilities are strategic substitutes, $t(1)$ is negative while $t(2)$ is positive, implying that the double difference is negative: being close to a hospital in $N$ magnifies the response of hospitals subject to the reform. These comparative statics properties are reported in cells B1 and B3 of Table 1.

Proximity of hospitals subject to the reform  

The proximity of hospitals in $S$ plays in the opposite direction. Consider the configuration shown on Figure 1(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 $d \nu_{N_2} = d \nu_{N_2'} = t(1) \Delta d r$ and $d \nu_{N_1} = t(2) \Delta d r$, which yields the double difference $d \nu_{N_2} - d \nu_{N_1} = d \nu_{N_2'} - d \nu_{N_1} = [t(1) - t(2)] \Delta d r$. 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 $S$ is associated with a stronger (resp. weaker) rise in patient gross utility. These comparative statics properties
**Table 1: Comparative statics properties for utility changes du\_h**

<table>
<thead>
<tr>
<th></th>
<th>Under strategic complementarity</th>
<th>Under strategic substitutability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>h ∈ S</td>
<td>h ∈ N</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>A. Own unused capacity</td>
<td>+(^<em>(</em>))</td>
<td>-</td>
</tr>
<tr>
<td>B. Proximity and unused capacity of competitors k ∈ N</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C. Proximity and unused capacity of competitors k ∈ S</td>
<td>+(^<em>(</em>))</td>
<td>+(^<em>(</em>))</td>
</tr>
</tbody>
</table>

*Notes:* The negative sign in cell B1 means that under strategic complementarity, the response of hospital \( h \) in \( S \) (relative to that of other hospitals in \( S \)) is lower when \( h \) is closer to hospitals \( k \) in \( N \) with larger unused capacities. Cells B1 and B3 are based on the configuration of Figure 1(b). Cells C2 and C4 are based on that of Figure 1(c). Cells A1, C1, A3, and C3 are based on Figure 1(d). Cells A2, B2, A4, and B4 are based on Figure 3. The results marked with \(^*(*)\) assume that the comparative statics regarding unused capacities is primarily governed by the direct effect.

are reported in cells C2 and C4 of Table 1.

### 4.4 Capacity utilization and hospital costs

In this section, we investigate how unused capacities at neighboring hospitals in \( N \) and in \( S \) 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 \( S \)) and the slopes of reaction functions. We conclude that unused capacity plays in the same direction as proximity. The proofs are based on the study of double differences and the results closely parallel the empirical findings presented below. The reader who is primarily interested in the empirical application should proceed directly to Section 5.

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 $S$) and lower slopes of the reaction functions.

**Proof.** Considering first direct effects, we see from (11) that the magnitude of $\Delta_h$ 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, $\Delta_h dr_h$ for $h \in S$, 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 $\rho_h$, 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 $\rho_h$ when $h$ has more unused capacity. \[\square\]

**Unused capacities of hospitals in $N$** 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 $N$ on the response of neighboring hospitals in $S$, we revisit the case of Figure 1(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 $du_{s_1} - du_{s_2}$ 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 $\Delta d r > 0$. We check in Appendix A that the magnitude of the double difference $d u_{S_1} - d u_{S_2}$ 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 1.

To understand the impact of the unused capacity of a hospital in $N$ on its own response or on that of neighboring hospitals also in $N$, we consider the configuration with five hospitals shown on Figure 3 in Appendix. (We use this more complicated configuration because we need a hospital in $S$ for the reform to have an effect.) The results reported in cells A2 and A4 of Table 1 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 $S$** 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 $S$ on the response of neighboring hospitals in $N$, we consider the configuration shown on Figure 1(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 $\Delta d r$ and the lower the slope of the reaction function, $\rho_S$. We find in Appendix that under strategic substitutability ($\rho_N < 0$) the double difference $d u_{N_2} - d u_{N_1}$ 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 1.

Finally, to understand the impact of the unused capacity of a hospital in $S$ on its own response or on that of neighboring hospitals also in $S$, we consider the configuration shown on Figure 1(d), with four hospitals subject to the reform. We check in appendix that the double differences $d u_{S_2} - d u_{S_1}$, $d u_{S_3} - d u_{S_2}$ and $d u_{S_3} - d u_{S_1}$ 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 1.\textsuperscript{13}

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 in the linear specification if and only if $\alpha b_h - 2a_h > 0$. Under this assumption, we can let the marginal utility of revenue $\lambda_h$ vary between zero and a maximum threshold, and we observe that the direct effect $\Delta_h$ increases with $\lambda_h$ over this interval.\textsuperscript{14} Following the same analysis as above (effect of own unused capacities, cells A1 and A3 of Table 1), 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 $d u_h$ 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, $\bar{R}_h$, play no role in the analysis.

In general, however, the presence of an income effect could reverse the reimbursement incentives, making the sign of $\Delta_h$ 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, $d r_h \geq 0$, there exist variations of the fixed transfers $d \bar{R}_h$ such that the revenue of each hospital is the

\textsuperscript{13}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 1. This slope, however, is decreasing in $b_h$ under strategic complementarity, which may weaken the predictions reported in cells B2 and B4.

\textsuperscript{14}The effect of $\lambda_h$ on the slope of its reaction function, $\rho_h$, is not obvious as $\lambda_h$ interacts with $c_h$ and $1/w_h$ in (12).
same before and after the reform.\footnote{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.} In such an environment, where income effects are neutralized, the \textit{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 administrative sources: \textit{Programme de Médicalisation des Systèmes d’Information} and \textit{Statistique Annuelle des Établissements de santé}. Both sources are based on mandatory reporting by each and any hospital in France, and therefore are 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 bed capacity. We also collected demographic variables at the French \textit{département} level,\footnote{Mainland France is divided in 94 administrative \textit{départements} with about 650,000 inhabitants on average.} 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 take the most comprehensive view of hospital activity. We only remove errors (invalid time or zip codes), missing values, and outliers from the data. We select patients coming from home because we use the patients’ home addresses. We drop observations with travel time above 150 minutes because they may correspond to patients who need surgery while on vacation far from their home. Overall, we keep 98\% of all surgery admissions. Our working sample contains about 5.2 million admissions per year.
5.1 Competition and financial indicators

We define the following indicators of exposure to competition from hospitals respectively subject and not subject to the reform:

\[
\text{comp}^S_h = \sum_{k \neq h, k \in S} e^{-\alpha d_{hk}} UC_{k,04}/1000
\]

\[
\text{comp}^N_h = \sum_{k \neq h, k \in N} e^{-\alpha d_{hk}} UC_{k,04}/1000.
\]

Following the analysis developed in Sections 4.3 and 4.4, the competition indicators are based on the proximity and unused capacities (UC in short) of competitors. Our measure of unused capacity, UC_{k,04}, is the difference between the maximal and the actual number of patient nights prior to the reform (i.e., in year 2004). The maximal number of beds times is computed as the hospital surgery bed capacity multiplied by 366 nights.

The above sums are computed for all hospitals \( k \neq h \) in mainland France. For each hospital \( h \), we count the amount of unused capacity in 2004 for all hospitals (separately in \( S \) and in \( N \)) weighted by an exponentially decreasing function of the travel time to hospital \( h \). Travel times are expressed in minutes. We set the parameter \( \alpha \) to .04, our preferred estimate of patient travel costs.\(^{17}\) It follows that 1,000 beds 25 minutes away from a hospital have a contribution of \( \exp(-1) \approx .368 \) to its exposure indicator.

Summary statistics for the two competition indicators at the hospital level are presented in Table 3. The figures allow to assess the extent to which the average hospital \( h \) is exposed to competition from for-profit clinics \( (k \in N) \) and from nonprofit hospitals \( (k \in S) \). On average, in the sense of the proposed indicator, 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 deviations shows

\(^{17}\) The estimation of travel costs is independent from the definition of the competition indicators, see Section 6.
that the competition indicators exhibit quite large variations across hospitals.

As explained in the introduction, we use hospitals’ debt ratios (debt over total assets) as proxies for their marginal utility of income. This indicator is available in the database for (almost all) government-owned hospitals, but not for private clinics. As shown on Table 3, debt represents 36% of assets for the average government-owned hospital, and the dispersion of the debt ratio is lower than that of the competition indicators.

5.2 Aggregation level

We do not use the DRG classification to describe hospital choice. Indeed, there are hundreds of diagnosis-related groups and the classification is abstract from the perspective of patients and general practitioners (GP) who address them to hospitals. We believe that the notion of clinical department is better adapted. For instance, a GP may trust a particular surgeon, medical team or service within a given hospital, and that trust generally extends beyond a narrow set of DRG codes. There are 19 clinical departments, among which orthopedics, ENT-stomatology, ophthalmology, gastroenterology, gynaecology, dermatology, nephrology and circulatory system account for 92.4% of total activity.\(^{18}\)

The purpose of this study is to assess the way hospitals have changed the average gross utility supplied to patients in response to a change in reimbursement incentives. 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 zip code; Paris, on the other hand, has 20 zip codes or arrondissements, and the second and third largest cities (Marseilles and Lyon) also have many zip codes.\(^{19}\) We define “demand units” as triples (clinical department, patient location, year) for which at least one patient admission occurred, i.e., for which \(n_{gzt} > 0\). As shown in Table 5, 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 \((g, z, t)\), we observe the number \(n_{gzt}\) of admissions for any hospital \(h\) that receives at least one patient from that unit. We therefore have: \(n_{gzt} = \sum_h n_{ghzt}\). The local share of hospital \(h\) in the demand unit \((g, z, t)\) is

\(^{18}\)The shares of each clinical department in number of surgery stays at the national level are shown in Table 13.

\(^{19}\)All distances in the paper are based on the center of the corresponding zip codes, and are computed with INRA’s Odomatrix software.
In Table 6, we present the distribution of local share and travel time per admission (each \((g, h, z, t)\) observation is weighted by the corresponding number of admissions \(n_{ghzt}\)). 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.

\section{A structural model of hospital choice}

Our econometric specification of patient demand is consistent with the additive model (1). For patient \(i\) living at location (zip code) \(z\) and seeking surgery care in clinical department \(g\) at date \(t\), the net utility from undergoing treatment in hospital \(h\) is

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

where \(d_{hz}\) denotes the travel time between patient home and hospital location.\(^{20}\)

The first term in (18), \(u_{ght}\), 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 \(\xi_{ghzt}\) 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 practicing in a given area may have connections to a particular hospital and tend to refer their patients to that hospital.

Finally, the term \(\varepsilon_{ighzt}\) is an idiosyncratic shock at the patient level. As is standard in the literature, we assume that \(\varepsilon_{ighzt}\) is an i.i.d. extreme value error term, which yields the theoretical local market shares:

\[ s_{ghzt} = \frac{e^{-\alpha d_{hz} + u_{ght} + \xi_{ghzt}}}{\sum_k e^{-\alpha d_{kz} + u_{gkt} + \xi_{gkzt}}}, \tag{19} \]

\(^{20}\)We also include the square of travel time in an alternative specification. We have also estimated models where the parameter \(\alpha\) depends on the year and on the clinical department.
where the denominator includes all hospitals in mainland France.\footnote{The identification issue in Footnote 10 is not present here: the level of $\alpha$ is identified by the normalization of the variance of the $\varepsilon_{ghzt}$’s.}

Identification is achieved by exclusion restrictions. Following many existing studies,\footnote{See, e.g., Kessler and McClellan (2000), Cooper, Gibbons, Jones, and McGuire (2011), Gowrisankaran, Lucarelli, Schmidt-Dengler, and Town (2011).} we assume that the shocks $\xi_{ghzt}$ are orthogonal to the market configuration, i.e., to the location of hospitals relative to that of patients, and to whether or not they are subject to the reform:

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

(20)

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. Similarly, the competition and financial indicators, which are evaluated in 2004, are assumed to be orthogonal to demand or cost shocks that might occur after 2005.

As regards the estimation strategy, we proceed in two steps. First, to estimate disutility travel costs, we present a novel method that avoids choice set restrictions or normalization assumptions. Then we place structure on utility variations and relate that structure to the theoretical framework developed in Section 4.

### 6.1 Estimation of travel costs

Two related issues about individual choice sets and market definition are critical for demand estimation. First, as is standard in the literature, we do not consider the option of not receiving surgery care, and 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.

Second, and more importantly, we depart from the many existing studies that restrict patient choice sets, typically by 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 or from a main city’s center. For instance, Kessler and McClellan (2000), Tay (2003), Ho (2006), and Ho and Pakes (2014) assume a maximum threshold for the distance that patients consider traveling to visit a hospital, and then check for the robustness of the results to the chosen threshold. In a similar spirit, Gowrisankaran, Lucarelli, Schmidt-Dengler, and Town (2011) define, for each patient location, an “outside good” as the set of all hospitals outside of a given radius and normalize the patient net utility for that good to zero. This leads to the standard Logit regression:

\[
\ln s_{ghzt} - \ln s_{g0zt} = -\alpha d_{hz} + u_{ght} + \xi_{ghzt}.
\]  

(21)

This method has the advantage of being easy to explain and to implement, and for this reason we use it as a benchmark. Yet the normalization of the outside good’s utility 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 (20) hold in the whole population, the estimation of (21) is based only on those observations with \( s_{ghzt} > 0 \). If a patient located at zip code \( z \) gets treated in a distant hospital \( h \), it might be because \( \xi_{ghzt} \) is large at that patient location, suggesting that, conditional on \( s_{ghzt} > 0 \), the variables \( d_{hz} \) and \( \xi_{ghzt} \) might be positively correlated. Such a correlation would generate a downward bias in the estimation of \( \alpha \). The researcher would mistakenly believe that patients do not dislike distance very much while in fact \( \xi_{ghzt} \) is high when hospital \( h \) and zip code \( z \) are far apart.

We now suggest an alternative method that partially addresses the above concerns.\(^{23}\) 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 administrative département; (ii) the hospital in \( S \) with the highest number of surgery beds in the patient’s département; (iii) the hospital in \( N \) with the highest number of surgery beds in

---

\(^{23}\)A complete treatment of the selection issue is outside the scope of the present study. For recent research on this difficult problem, see Gandhi, Lu, and Shi (2013).
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

\[ \ln s_{ghzt} - \ln s_{gh^{\text{ref}}(z)zt} = -\alpha[d_{hz} - d_{h^{\text{ref}}(z)z}] + [u_{ght} - u_{gh^{\text{ref}}(z)t}] + [\xi_{ghzt} - \xi_{gh^{\text{ref}}(z)zt}). \] (22)

To estimate these equations, we compute the dependent variable by using the empirical counterparts of the local market shares, \( \hat{s}_{ghzt} = n_{ghzt}/n_{gz} \), where \( n_{gz} = \sum h n_{ghzt} \) 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 \( n_{gz} \), which is close to 15 on average, see Table 5. 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.

The parameter \( \alpha \) is identified by variations of local shares and distances in the zip code dimension. Indeed, consider the set of all zip codes \( z \) that send patients to their reference hospitals \( h^{\text{ref}}(z) \) and to another hospital \( h \). Figure 2 shows two such zip codes, \( z \) and \( z' \). The utility 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:

\[ W^z \ln \frac{s_{ghzt}}{s_{gh^{\text{ref}}(z)zt}} = -\alpha W^z[d_{hz} - d_{h^{\text{ref}}(z)z}] + v_{ghzt}, \] (23)

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

\[ W^z x_{ghzt} = x_{ghzt} - \frac{1}{|Z_{h^{\text{ref}}(z)}|} \sum_{z' \in Z_{h^{\text{ref}}(z)}} x_{ghzt}, \] (24)

where \( Z_{h^{\text{ref}}(z)} \) is the set of zip code 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 zip codes per pair used for estimation. The direction of a potential selection bias is more ambiguous for equation (23) than it is for equation (21), because the possible positive correlation between \( d_{hz} \) and \( \xi_{hz} \) holds for both \( h \) and \( h^{\text{ref}} \) and the effect on the differences

The three definitions of the reference hospital are different as the largest hospital in the \textit{département} belongs to the subset \( S \) for 70 \textit{départements} and to the subset \( N \) for 24 \textit{départements}. See also Footnote 16.
Figure 2: Double difference (in the zip code dimension) estimator

\[ d_{hz} - d_{h^*z} \] and \( \xi_{hz} - \xi_{h^*z} \) is a priori unclear. Finally, we note that under this “triangulation” method, the identification of \( \alpha \) comes from the \( z \) dimension, and therefore it is possible to estimate \( \alpha \) for each clinical department and each year separately.

### 6.2 Utility variations

The time differences \( u^{ght} - u^{gh2005} \) for \( t > 2005 \) are the empirical counterparts of the utility variations \( du_h \) 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 \( \alpha \) 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.

We specify hospital attractiveness as follows:

\[
u^{ght} = \beta^N_{ht} N_h + \beta^S_{ht} S_h + \gamma X_{ht} + A_{gt} + B_{gh}, \tag{25}\]

where \( N_h \) and \( S_h \) are dummy variables for being respectively not subject and subject to the reform. The parameters \( \beta^N_{ht} \) and \( \beta^S_{ht} \) therefore represent the evolution of the utilities supplied by hospitals \( h \) in \( N \) and \( S \). We include clinical department-hospital fixed effects \( B_{gh} \) to account for the hospital reputation in each clinical department. We therefore identify only changes in attractiveness and normalize the parameters \( \beta^N_{ht} \) and \( \beta^S_{ht} \) to zero at the beginning of the phase-in period, i.e., \( \beta^N_{h,05} = \beta^S_{h,05} = 0 \). We also 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 administrative département where the hospital is located. Finally, to control for national trends in the utilization of hospital care, we include clinical department-time fixed effects $A_{gt}$.

Next we place structure on the parameters $\beta_{ht}^N$ and $\beta_{ht}^S$ to explain utility variations between and within each of the two groups $N$ and $S$:

$$
\begin{align*}
\beta_{ht}^N &= \beta_{t}^{NC} U_{h,04} + \beta_{t}^{NS} \text{comp}^S_h + \beta_{t}^{NN} \text{comp}^N_h, \\
\beta_{ht}^S &= \beta_{t}^{S0} + \beta_{t}^{SC} U_{h,04} + \beta_{t}^{SS} \text{comp}^S_h + \beta_{t}^{SN} \text{comp}^N_h.
\end{align*}
$$

As already mentioned, all the parameters are normalized to zero at the first year of the period, $t = 2005$. Because $N_h + S_h = 1$ and time fixed effects are included in (25), we do not interact time with the dummy $N_h$, i.e., we impose $\beta_{0}^{N0} = 0$. In other words, we allow for different trends for hospitals subject and not subject to the reform. The difference in mean utility changes within the two subgroups $N$ and $S$ is nothing but the “average relative effect” defined by the left-hand side of equation (13).

We let utility changes depend on the firms’ unused capacity (UC) the year before the beginning of the phase-in period. We have argued in Section 4.4 that higher amounts of unused capacities are associated with stronger direct effects for hospitals in $S$ because those capacities make it easier for the hospitals to react to the newly created incentives. We have also noticed that large unused capacities are also associated with lower slopes of reaction functions for hospitals in $N$ because they weaken the forces pushing towards strategic complementarity. Then, relying on a simplified linear model, we have found the effects of capacities on responses that are reported on line A of Table 1. The above intuitions translate into the signs of coefficients $\beta_{t}^{NC}$ and $\beta_{t}^{SC}$ in (26) that are reported on line A of Table 2.

More importantly, we let utility changes depend on the hospital competitive environment, namely, the proximity and unused capacities of neighboring hospitals as encompassed in the indicators $\text{comp}^N$ and $\text{comp}^S$ defined by (16) and (17). Based on the same simplified model, we have found in Section 4 that under strategic complementarity the proximity and unused capacity of hospitals (not) subject to the reform magnifies (attenuates) hospital responses, and that these results are reversed under strategic substitutability. The intuition is that hospitals in $S$ with much unused capacities react strongly to the new incentives (“direct effect”) and that these strong responses, under strategic complementarity, propagate to

---

25In some specifications, we let the various coefficients $\beta$ depend on the clinical department $g$. 28
Table 2: Impact of competitive environment on utility changes

<table>
<thead>
<tr>
<th></th>
<th>Under strategic complementarity</th>
<th>Under strategic substitutability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$h \in S$</td>
<td>$h \in N$</td>
</tr>
<tr>
<td></td>
<td>$h \in S$</td>
<td>$h \in N$</td>
</tr>
<tr>
<td>A. Own unused capacity</td>
<td>$\beta_{tSC}^C &gt; 0$</td>
<td>$\beta_{tNS}^C &lt; 0$</td>
</tr>
<tr>
<td></td>
<td>$\beta_{tNC}^C &lt; 0$</td>
<td>$\beta_{tNS}^C &gt; 0$</td>
</tr>
<tr>
<td>B. Proximity and unused capacity of competitors $k \in N$</td>
<td>$\beta_{tSN}^C &lt; 0$</td>
<td>$\beta_{tNS}^C &gt; 0$</td>
</tr>
<tr>
<td></td>
<td>$\beta_{tNN}^C &lt; 0$</td>
<td>$\beta_{tNS}^C &gt; 0$</td>
</tr>
<tr>
<td>C. Proximity and unused capacity of competitors $k \in S$</td>
<td>$\beta_{tSS}^C &gt; 0$</td>
<td>$\beta_{tNS}^C &lt; 0$</td>
</tr>
<tr>
<td></td>
<td>$\beta_{tNS}^C &gt; 0$</td>
<td>$\beta_{tNS}^C &gt; 0$</td>
</tr>
</tbody>
</table>

*Note:* The above expected signs, which parallel those reported in Table 1, apply to the coefficients in the baseline specification (26). See the note below Table 1 for interpretations.

immediate neighbors; on the contrary, the proximity of large clinics in $N$, which are relatively inert, tends to attenuate the response of nearby hospitals, hence the results reported in cells C1 and C2 of Table 1. These intuitions translate into the signs of coefficients $\beta_{NS}^N$, $\beta_{SS}^N$, and $\beta_{SS}^C$ in (26) that are reported on lines B and C of Table 2.

Finally, in an extension, we let utility changes for hospitals in $S$ depend also on their debt ratio (evaluated before the beginning of the phase-in period). If more indebted hospitals have a higher marginal utility for revenue, those hospitals should respond more vigorously to the reform, relative to other less indebted hospitals in $S$, see Section 4.5. Due to data limitations, we observe this financial ratio for government-owned hospitals only. We therefore have first to distinguish hospitals in $S$ according to their ownership status. Then we can compare the responses of more or less indebted government-owned hospitals.

Turning to estimation, we first compute the competition indicators $\text{comp}_h^N$ and $\text{comp}_h^S$ defined by (16) and (17), using the estimated value of $\alpha$ obtained above. The relative changes in the gross utilities supplied by the hospitals are identified in the time dimension, while absolute utility levels remain unidentified. First-differencing equation (22) between year $t$ and year 2005, and using (25) and (26),
where \( w_{ghzt} = (\xi_{ghzt} - \xi_{ghref(z)zt}) - (\xi_{ghz,05} - \xi_{ghref(z)z,05}) \), \( t > 2005 \). We also estimate a model where utility changes depend furthermore on ownership status and, among government-owned hospitals, on debt ratio. The estimating equation is derived in the same way as above.

### 7 Results

As discussed in Section 6.1, we start by estimating a Logit regression with an “outside good” defined, for each patient location, as the set of hospitals outside of a given radius. Table 7 reports the estimation results for equation (21) with a one-hour cutoff radius. The first line of the table shows an estimated travel disutility cost of .025 per minute, which we discuss in greater detail below. Regarding utility variations, the first column shows the estimation results for our baseline specification –equation (26)– while the second column includes the ownership status of hospitals in \( S \) and the debt ratio of government-owned hospitals.\(^{26}\)

Panels A1 to C2 of Table 7 are labelled as the corresponding cells of Tables 1 and 2. The reported signs are indeed consistent with the left part of those tables, i.e., with strategic complementarity. More specifically, the impact of competition on hospital responses is shown in panels B1 to C2. We find that the proximity

\(^{26}\)Financial indicators are available in the database for government-owned hospitals only.
of hospitals (not) subject to the reform is associated with a stronger (weaker) increase in the utility provided to patients, both for hospitals in $N$ and in $S$. This suggests that the utilities supplied by the hospitals are strategic complements. The results are statistically significant for all coefficients in panels B1 to C2 under the baseline specification. We obtain less significance when the debt ratio is included in the regression equation. Moreover, according to the estimates reported in panel F, more indebted government-owned hospitals do not appear to have responded more vigorously to the reform.

The effect of unused capacities on hospital responses is consistent with theory. Panel A1 shows that among hospitals in $S$ those with more unused capacity in 2004 react more vigorously to the reform. For hospitals in $N$, however, we do not find any significant negative effect.

Next, we proceed to our preferred estimation approach, which is based on utility differences relative to a reference hospital as shown in equation (22). Table 8 reports the disutility cost of travel time for the three choices of reference hospital. The number of observations for which the term $\ln s_{ghzt} - \ln s_{gh^{ref}(z)zt}$ is defined at the left-hand side of the triangulation equation (23) varies across columns, i.e., with the definition of the reference hospital. We find an estimated cost $\alpha$ of about .040 per minute, highly significant because of the very rich variation in the zip code dimension. The estimate found with the outside good approach, .025, might therefore be biased downwards as suggested in Section 6.1. In Table 9, we reiterate the estimation of travel costs after dropping hospital pairs $(h, h^{ref}(z))$ on the basis of which few zip codes can be used for triangulation, i.e., for which the cardinal of the set $Z_{hh^{ref}(z)}$ defined below (24) is lower than or equal to various thresholds. The estimate of $\alpha$ appears to be extremely robust to the chosen threshold.

Returning to the study of utility variations, Table 10 presents the estimation results for the baseline specification (26). The results shown in panels A1 to C2 coincide remarkably with the expected effects reported in the corresponding cells of Tables 1 and 2, with high levels of statistical significance. In particular, panels B1 to C2, which allow to discriminate between strategic complementarity and strategic substitutability, strongly support the former hypothesis. As regards the effects of own unused capacity, panels A1 and A2, too, are consistent with theory.

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27 Estimating travel costs separately for each of the eight main clinical departments shown in Table 13 yields estimates comprised between .035 and .046. We have also checked the travel cost estimates vary very little over the four years of the period of interest.
In all specifications, the average income and the population density of the administrative département are included in the covariates $X_{ht}$ of equation (25). These two variables turn out to have a significantly positive effect on the utility variations. These effects are not shown in the tables due to space limitations.

**Average relative effect of the reform** The analysis developed in Section 4.3 suggests that the utility supplied to patients should increase more rapidly for hospitals in $S$ than for hospitals in $N$, recall inequality (13). The following ratio expresses the average relative effect in terms of travel time

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

We estimate the standard error of the above ratio by non-parametric bootstrap. We proceed to 200 draws with replacement from the data set at the $(g,h,z,t)$ level, estimate (23) and (27) in each of the replicated sample, and compute the standard deviation of the ratio $\tau^0_t$.

Table 11 shows that the average relative effect of the reform increases over time as hospital incentives are being gradually strengthened. After complete implementation of the reform, i.e., in year 2008, the magnitude of the effect is of little less than two minutes and is highly significant. This effect is sizeable as two minutes represent about 9% of the median travel time to hospitals for surgery admissions. The table also shows that the estimated average relative effect is moderately sensitive to the definition of the reference hospitals, with an effect comprised between 1.6 and 2 minutes in year 2008 for the three definitions. Table 12 shows that the estimated effect does not change dramatically when demand units with small numbers of patients are excluded from the sample. For instance, if we consider demand units with at least 50 patients ($n_{gzt} > 50$), the estimated effect is close to 1.4 minute.

Table 13 shows the average relative effects of the reform by clinical departments. These effects are obtained by estimating the model separately for each of the eight main clinical departments (that together account for more than 92% of all surgery admissions). The separate estimations imply that the coefficients in equations (23) and (27) are allowed to depend on the clinical department.\(^{28}\) We only report the

\(^{28}\) On the contrary, to obtain Tables 10, 11 and 12, we constrain those coefficients to be uniform across departments, which make the bracketed term in (28) independent of $g$ as the fixed effects $A_{gt}$ and $B_{gh}$ cancel out.
average relative effects at the end of the phase-in period, i.e., in 2008. We find that those effects vary across clinical departments between 0.6 and 4.7 minutes, i.e., between 3% and 20% of the median travel time in each department. The weakest effect, 3%, is found for orthopedics, the department with the largest number of admissions. By contrast, the second largest department, stomatology, experienced one of the strongest effects, 18%.

Assessing the strength of strategic interactions The main purpose of this article is to understand the nature and strength of competitive forces in the hospital industry. As already seen, panel B1 to C2 of Table 10 support strategic complementarity. We now want to express the intensity of competitive forces in a concrete manner. To this aim, we consider one-standard-deviation increases in the competition indicators $\text{comp}^N$ and $\text{comp}^S$. For instance,

$$\tau_{SN} = \frac{\hat{\beta}_{SN} \text{ S.D.} (\text{comp}^N | S)}{\hat{\alpha}} \tag{29}$$

measures the effect on the response of a hospital in $S$ of a one-standard-deviation increase in exposure to competition from hospitals in $N$. Coefficients $\tau_{SS}$, $\tau_{NS}$, and $\tau_{NN}$ are similarly defined. Standard errors for these parameters are estimated by bootstrap as explained above.

Table 14 shows that the complementarity between reimbursement incentives and competitive forces is strong. To illustrate, for a hospital in $S$, a one-standard-deviation increase in exposure to competition from hospitals also in $S$ raises the response by 2.3 minutes, that is, by the same order of magnitude as the average relative effect; similarly, a one-standard-deviation increase in exposure to competition from hospitals in $N$ decreases the response by 2.4 minutes. The order of magnitude of each of the two competitive effects is one third lower when the concerned hospital is a private clinic not subject to the reform (1.5 minutes instead of 2.3 on the one hand, -1.7 minutes instead of -2.4 on the other hand).

Marginal utility of income Table 15 shows the estimation results for a specification that includes furthermore the ownership status of hospitals in $S$ and the debt ratio of government-owned hospitals. The structure of the table is the same as above, with all (but one) coefficients in panels A1 to C2 being significant and of

---

29 The standard deviations of the indicators within each of the two subgroups $N$ and $S$ are found in Table 3. For instance the standard deviation in (29) is .38.
the signs announced in the corresponding cells of Tables 1 and 2. Panel F reports the effect of the financial indicator. As predicted in Section 4.5, we find that a higher debt ratio before the reform is associated with a larger utility variation over the whole phase-in period of the reform, i.e., between 2005 and 2008. The following ratio expresses the effect of the financial indicator on utility changes in terms of extra travel time that patients are ready to incur

$$\tau_t^{SF} = \hat{\beta}_t^{SF} \text{S.D. (debt ratio | S)} \frac{\hat{\alpha}}{\hat{\alpha}}.$$

Table 16 shows that for hospitals subject to the reform, a one-standard-deviation increase in the debt ratio raises the response by .4 minute, about 20% of the average relative effect of the reform.

8 Concluding remarks

In many regulated industries, the economic agents subject to regulation interact strategically. Changing the regulatory rules shifts the equilibrium outcomes in ways that depend on the nature and strength of these strategic interactions. This article has considered the particular case of the hospital industry, exploiting the recent shift from global budgeting to prospective payment for nonprofit French hospitals. By estimating a structural model of hospital choice based on all surgery admissions over this period, we have documented a strong complementarity between reimbursement incentives and nonprice 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, 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 strongly support strategic complementarity.

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 should therefore anticipate correctly the effect of competition when changing reimbursement incentives.

Although we have confined ourselves to a positive analysis, 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. Our empirical results demonstrate the equally important role of intra-sector competition.

A natural extension of this study is to link the shifts in patient flows to actions taken by hospitals. To increase their relative attractiveness and gain market shares, they may change technological processes, 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 can to some extent 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, a task that we leave for future research.

References


30Our 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.

31An example of particular interest is the development of outpatient care.


A Comparative statics in the linear model

In the linear model, the hospital objective function is

\[ V^h = [\lambda_h r_h - \lambda_h c_{oh} + \lambda_h e + v_h + (a_h - \lambda_h c_h)u] s - \frac{b_h}{2} u^2 - \frac{w_h}{2} c^2 + \lambda_h (R_h - F_h), \]

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 \( \rho_h = -(\partial \mu^h/\partial u_{-h}) / (\partial \mu^h/\partial u_h) \). 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 \( \rho_h \) is given by the sign of \( (\lambda_h c_h - a_h)/\alpha - \lambda_h^2/(\alpha w_h) \alpha^2 \) as indicated in Section 4.2.

**Role of cost parameters** We now check that \( \rho_h \) increases with \( c_h \) or equivalently in \( \lambda_h c_h \) at given \( \lambda_h \). 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 \( \rho_h \) increases with \( w_h \) or equivalently with \( z_h = -\lambda_h^2/(\alpha w_h) \) at given \( \lambda_h \) and \( \alpha \). 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 \( \rho_h \) is below its horizontal asymptote, \( \rho_h < 1/2 \), and since we are at the right of its vertical
asymptote, $\rho_h$ 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

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

(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.\(^{32}\) 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

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

(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 $N$** We consider the situation represented on Figure 1(b) with three symmetric hospital in $S$ and one hospital in $N$. Denoting by $\rho_S$ the common slope of reaction functions of $S_1$, $S_2$ and $S_2'$ and $\rho_N$ 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

$$
F = \begin{bmatrix}
1 & -\rho_S & 0 & -\rho_S \\
-\rho_S & 1 & -\rho_S & 0 \\
0 & -\rho_N & 1 & -\rho_N \\
-\rho_S & 0 & -\rho_S & 1 \\
\end{bmatrix}
$$

(A.3)

\(^{32}\)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 $du_i = [t_{i1} + t_{i2} + t_{i4}] \Delta dr$, we check that
\[ du_{S1} - du_{S2} = \frac{\rho_S - 2\rho_S \rho_N}{1 - 2\rho_S^2 - 2\rho_S \rho_N} \Delta dr. \]

It is easy to check that $du_{S1} - du_{S2}$ decreases (increases) with $\rho_N$ 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, $\rho_N$, hence the results announced in the text.

To study the impact of unused capacities of hospitals in $N$ on the responses of hospitals also in $N$, we consider the configuration shown on Figure 3 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 $\rho^h$ 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.

We assume that $N_1$, $N_2$ and $N_2'$ have the same cost and preference parameters and denote by $\rho_N$ 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 $du_{N_1} - du_{N_2}$. We denote by $\rho_3$ and $\rho_S$ 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

$$F = \begin{bmatrix}
1 & -\rho_N & 0 & -\rho_N & -\rho_N \\
-\rho_N & 1 & -\rho_N & 0 & -\rho_N \\
0 & -\rho_3 & 1 & -\rho_3 & -\rho_3 \\
-\rho_N & 0 & -\rho_N & 1 & -\rho_N \\
-\rho_S & -\rho_S & -\rho_S & -\rho_S & 1
\end{bmatrix}.$$  \hspace{1cm} (A.4)

Computing $T = F^{-1}$ and using $du_i = t_i \Delta dr$, we check that $du_{N_2} - du_{N_1}$, $du_{N_3} - du_{N_1}$ and $du_{N_3} - du_{N_2}$ increases (decreases) with $\rho_3$ 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 1, and with a weaker response of $N_3$ relative to that of both $N_1$ and $N_2$, as reported in cell A2 of Table 1. The result is reversed under strategic substitutability (cells A4 and B4).

**Unused capacities of hospitals in $S$** We consider the situation represented on Figure 1(c) with three symmetric hospital in $N$ and one hospital in $S$, 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 $\rho_N$ and $\rho_S$. Computing $T = F^{-1}$ and using $du_i = t_i \Delta dr$, we check that

$$du_{N_2} - du_{N_1} = \frac{\rho_N - 2\rho_N^2}{1 - 2\rho_N^2 - 2\rho_N \rho_S} \Delta dr.$$

The amount of unused capacity of hospital $S$ has a negative impact on $\rho_S$ and a positive one on the direct effect $\Delta dr$, both of which affecting $du_{N_2} - du_{N_1}$. If $\rho_N < 0$, $du_{N_2} - du_{N_1}$ 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 $\Delta$ dominates the change in the slope $\rho_S$.

We now consider the case with four hospitals subject to reform, Figure 1(d), three of them being symmetric, $S_1$, $S_2$ and $S_2'$ and the last one being denoted by $S_3$. We call $\rho_S$ and $\rho_3$ the slopes of corresponding reaction functions. The matrix $F$ is obtained from (A.3) by replacing $\rho_N$ with $\rho_3$. Denoting by $\Delta_S$ and $\Delta_3$ the direct effects, we have $du_i = [t_{i1} + t_{i2} + t_{i4}] \Delta_S dr + t_{i3} \Delta_3 dr$. The unused capacity of hospital $S_3$ affects both $\rho_3$ and $\Delta_3$. The double difference $du_{S_2} - du_{S_1}$, is linear in $\Delta_3 dr$, with the contribution of $\Delta_3$ being

$$\frac{\rho_S(1 - 2\rho_S)}{1 - 2\rho_S^2 - 2\rho_S \rho_3} \Delta_3 dr.$$
This double difference therefore increases (decreases) with $\Delta_3$ if $\rho_S > 0$ ($\rho_S < 0$), hence the results reported in cells C1 and C3 of Table 1. It is easy to check that the differences $du_{S_3} - du_{S_1}$ and $du_{S_3} - du_{S_2}$ is linearly increasing in $\Delta_3$, 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:

$$\mu^h(u_h, u_h, r_h, \bar{R}_h) = V^h_{\pi} \left[ [r_h - (c_{0h} + c_h u_h)]s_h - c_h s^h \right] + V^h_s s^h + V^h_u,$$

where a subscript indicates partial differentiation. The hospital revenue enters the (possibly endogenous) marginal utility of revenue, $\lambda_h = V^h_{\pi}$, as well as possibly the partial derivatives $V^h_N$ and $V^h_u$. Concentrating on the first term of the above sum, we observe that $r_h V^h_{\pi} s^h$ increases in $r_h$ if $V^h_{\pi}$ is fixed. Yet a rise in $r_h$ may increase the hospital revenue, thus lowering $V^h_{\pi}$ 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

$$D_u \mu . du + \Delta dr = 0,$$

where $\Delta$ is the diagonal matrix with $\lambda_h s^h$ on its diagonal. To keep hospital revenues fixed, the government must change the lump-sum transfers by $d\bar{R}_h = -s^h dr_h - r_h ds^h$, where $ds^h = d_u s^h . du$ and $du$ 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 $(\bar{R}_h + d\bar{R}_h, r_h + dr_h)$ increases reimbursement incentives while neutralizing income effects.
Table 3: Summary statistics at the hospital level

<table>
<thead>
<tr>
<th></th>
<th>Gov-owned</th>
<th>Private nonprofit</th>
<th>Together</th>
<th>For-profit clinics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td># of hospitals</td>
<td>477</td>
<td>111</td>
<td>588</td>
<td>565</td>
<td>1,153</td>
</tr>
<tr>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
</tr>
<tr>
<td># stays in 2005</td>
<td>3,763.1 (5,250.1)</td>
<td>2,181.2 (2,334.5)</td>
<td>3,464.5 (4,874.1)</td>
<td>5,459.7 (3,570.0)</td>
<td>4,442.2 (4,397.8)</td>
</tr>
<tr>
<td># stays in 2006</td>
<td>3,855.8 (5,416.9)</td>
<td>2,232.5 (2,449.3)</td>
<td>3,549.3 (5,032.1)</td>
<td>5,531.6 (3,608.3)</td>
<td>4,520.7 (4,501.1)</td>
</tr>
<tr>
<td># stays in 2007</td>
<td>3,896.9 (5,493.6)</td>
<td>2,293.6 (2,511.9)</td>
<td>3,597.0 (5,107.6)</td>
<td>5,446.5 (3,597.8)</td>
<td>4,503.3 (4,526.1)</td>
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<tr>
<td># stays in 2008</td>
<td>4,032.6 (5,737.1)</td>
<td>2,393.2 (2,627.9)</td>
<td>3,725.9 (5,332.7)</td>
<td>5,382.2 (3,638.0)</td>
<td>4,517.6 (4,653.6)</td>
</tr>
<tr>
<td># stays (2008 - 2005)</td>
<td>273.8 (662.5)</td>
<td>228.0 (651.3)</td>
<td>261.4 (663.0)</td>
<td>77.4 (1130.6)</td>
<td>95.4 (1093.2)</td>
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<td>Beds and unused capacity in 2004</td>
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<td></td>
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<tr>
<td># beds</td>
<td>100.7 (153.2)</td>
<td>58.1 (60.1)</td>
<td>25.9 (27.1)</td>
<td>25.9 (47.4)</td>
<td>34.6 (21.2)</td>
</tr>
<tr>
<td>Unused Capacity</td>
<td>33.9 (59.9)</td>
<td>25.9 (27.1)</td>
<td>25.9 (47.4)</td>
<td>34.6 (21.2)</td>
<td>33.5 (36.7)</td>
</tr>
<tr>
<td>Exposure to competition in 2004</td>
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<tr>
<td>comp\textsuperscript{N}</td>
<td>0.220 (0.351)</td>
<td>0.383 (0.467)</td>
<td>0.250 (0.380)</td>
<td>0.314 (0.423)</td>
<td>0.282 (0.404)</td>
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<tr>
<td>comp\textsuperscript{S}</td>
<td>0.154 (0.246)</td>
<td>0.323 (0.310)</td>
<td>0.185 (0.267)</td>
<td>0.261 (0.291)</td>
<td>0.223 (0.281)</td>
</tr>
<tr>
<td>Debt ratio</td>
<td>Debt / total assets</td>
<td>0.357 (0.162)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Sample. 1,153 hospitals in mainland France.
Note. Financial information available for 441 government-owned hospitals only.
Unused capacity in thousands bed-days.

Table 4: Difference in differences (per hospital and clinical department)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2008</th>
<th>2008 − 2005</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Number of stays</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not subject to the reform (N\textsuperscript{V})</td>
<td>399.5</td>
<td>(8.2)</td>
<td>409.4</td>
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<tr>
<td>Subject to the reform (S\textsuperscript{V})</td>
<td>256.2</td>
<td>(6.5)</td>
<td>279.9</td>
</tr>
<tr>
<td>S − N\textsuperscript{V}</td>
<td>-143.2</td>
<td>(10.4)</td>
<td>-129.5</td>
</tr>
</tbody>
</table>

Sample. 1,153 hospitals in mainland France.
Note. Number of stays per hospital, clinical dept, year.
### Table 5: Summary statistics at the \((g, z, t)\) level

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
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<tr>
<td>Number of patients</td>
<td>14.90</td>
<td>(79.46)</td>
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<tr>
<td>Number of hospitals</td>
<td>3.33</td>
<td>(4.59)</td>
</tr>
<tr>
<td>Number of observations ((g, z, t))</td>
<td>1,392,775</td>
<td></td>
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</tbody>
</table>


*Sample.* 1,153 hospitals in mainland France.

*Note.* 1,392,775 zip code × clinical department × year observations (20,753,308 discharges).

### Table 6: Summary statistics at the \((g, h, z, t)\) level

<table>
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<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>min</th>
<th>q10</th>
<th>q25</th>
<th>q50</th>
<th>q75</th>
<th>q90</th>
<th>max</th>
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<tr>
<td>Market share</td>
<td>0.322</td>
<td>(0.523)</td>
<td>0.000</td>
<td>0.038</td>
<td>0.120</td>
<td>0.278</td>
<td>0.474</td>
<td>0.667</td>
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<tr>
<td>Time (in minutes)</td>
<td>27.2</td>
<td>(54.7)</td>
<td>0.0</td>
<td>0.0</td>
<td>9.5</td>
<td>22.0</td>
<td>37.5</td>
<td>59.5</td>
<td>149.5</td>
</tr>
<tr>
<td>Number of observations ((g, h, z, t))</td>
<td>4,640,991</td>
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</tbody>
</table>


*Sample.* 1,153 hospitals in mainland France.

*Note.* 4,640,991 hospital × zip code × clinical department × year observations (20,753,308 discharges) weighted by surgical discharges \(n_{h, z, t}\).
Table 7: Using distant hospitals as an “outside good”

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<tbody>
<tr>
<td>S × UC2004 × 2006</td>
<td>0.123*** (0.031)</td>
<td>0.104*** (0.033)</td>
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<td>0.047*** (0.014)</td>
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<td>282783</td>
<td>0.275</td>
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<tr>
<td>S × UC2005 × 2007</td>
<td>0.075** (0.035)</td>
<td>0.044 (0.037)</td>
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<td>0.072*** (0.016)</td>
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<td>2627296</td>
<td>0.281</td>
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<tr>
<td>S × UC2006 × 2008</td>
<td>0.078** (0.032)</td>
<td>0.077** (0.033)</td>
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<td>0.104*** (0.017)</td>
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<td>282783</td>
<td>0.275</td>
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<tr>
<td>N × UC2004 × 2006</td>
<td>-0.160 (0.135)</td>
<td>-0.160 (0.138)</td>
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<td>0.021*** (0.012)</td>
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<td>2627296</td>
<td>0.281</td>
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<tr>
<td>N × UC2005 × 2007</td>
<td>0.022 (0.149)</td>
<td>0.027 (0.151)</td>
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<td>0.049*** (0.017)</td>
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<td>282783</td>
<td>0.275</td>
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<tr>
<td>N × UC2006 × 2008</td>
<td>0.005 (0.173)</td>
<td>0.003 (0.177)</td>
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<td>0.009*** (0.011)</td>
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<td>2627296</td>
<td>0.281</td>
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<tr>
<td>N × comp² × 2006</td>
<td>-0.053** (0.023)</td>
<td>0.004 (0.023)</td>
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<td>0.033*** (0.018)</td>
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<td>282783</td>
<td>0.275</td>
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<tr>
<td>N × comp² × 2007</td>
<td>-0.105*** (0.028)</td>
<td>-0.021 (0.023)</td>
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<td>0.032*** (0.017)</td>
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<tr>
<td>N × comp² × 2008</td>
<td>-0.081*** (0.031)</td>
<td>0.009 (0.021)</td>
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<td>0.033*** (0.018)</td>
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<tr>
<td>S × comp² × 2006</td>
<td>0.118*** (0.037)</td>
<td>0.056 (0.029)</td>
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<td>0.021*** (0.013)</td>
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<td>2627296</td>
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<tr>
<td>S × comp² × 2007</td>
<td>0.150*** (0.039)</td>
<td>0.164*** (0.052)</td>
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<td>0.022*** (0.013)</td>
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<tr>
<td>S × comp² × 2008</td>
<td>0.212*** (0.042)</td>
<td>0.146*** (0.056)</td>
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<tr>
<td>N × comp² × 2006</td>
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<td>0.054 (0.034)</td>
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<td>0.023*** (0.013)</td>
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<tr>
<td>N × comp² × 2007</td>
<td>0.183*** (0.038)</td>
<td>0.160*** (0.049)</td>
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<td>0.021*** (0.012)</td>
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<td>N × comp² × 2008</td>
<td>0.184*** (0.043)</td>
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<td>Pri-owned × 2006</td>
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<td>Gov-owned × debt ratio²004 × 2007</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gov-owned × debt ratio²004 × 2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sample: 1,153 hospitals in mainland France.
Notes: A market is defined as the set of hospitals within 60’ travel time.
Controls include density, income, population of h’s département. Robust standard errors in parentheses.
Panel labels in the right column (from A1 to C2) show the correspondence with the cells of Tables 1 and 2.
Table 8: Travel costs

<table>
<thead>
<tr>
<th>Reference hospital</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time</td>
<td>-0.040***</td>
<td>-0.040***</td>
<td>-0.042***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td># of pairs ((h, h^{ref}(z)))</td>
<td>13035</td>
<td>13036</td>
<td>13007</td>
</tr>
<tr>
<td>Average # of zip codes per pair</td>
<td>18.5</td>
<td>18.5</td>
<td>18.3</td>
</tr>
<tr>
<td>Observations</td>
<td>2758304</td>
<td>2650617</td>
<td>2319871</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.320</td>
<td>0.325</td>
<td>0.325</td>
</tr>
</tbody>
</table>

Sample. 1,153 hospitals in mainland France.
Note. Reference hospital:
(1) the largest in the \(d{\text{\textperiodcentered}}\)\(\text{epartement}\)
(2) the largest nonprofit in the \(d{\text{\textperiodcentered}}\)\(\text{epartement}\)
(3) the largest for-profit in the \(d{\text{\textperiodcentered}}\)\(\text{epartement}\)
Robust standard errors in parentheses.

Table 9: Travel costs, dropping hospital pairs with small number of zip codes

<table>
<thead>
<tr>
<th>Threshold</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time</td>
<td>-0.040***</td>
<td>-0.040***</td>
<td>-0.040***</td>
<td>-0.041***</td>
<td>-0.040***</td>
<td>-0.040***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Observations</td>
<td>2718684</td>
<td>2629416</td>
<td>2507354</td>
<td>2281277</td>
<td>1772162</td>
<td>1211473</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.320</td>
<td>0.320</td>
<td>0.320</td>
<td>0.321</td>
<td>0.308</td>
<td>0.267</td>
</tr>
</tbody>
</table>

Sample. 1,153 hospitals in mainland France.
Note. Reference hospital: the largest in the \(d{\text{\textperiodcentered}}\)\(\text{epartement}\)
Robust standard errors in parentheses.
Pairs \((h, h^{ref}(z))\) with at least \([\text{threshold}]\) zip codes.
Table 10: Estimation of the impact of competition

<table>
<thead>
<tr>
<th>Reference hospital</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S \times UC_{2004} \times 2006$</td>
<td>0.143*** (0.015)</td>
<td>0.148*** (0.015)</td>
<td>0.095*** (0.033)</td>
</tr>
<tr>
<td>$S \times UC_{2004} \times 2007$</td>
<td>0.088*** (0.016)</td>
<td>0.094*** (0.016)</td>
<td>0.029 (0.034)</td>
</tr>
<tr>
<td>$S \times UC_{2004} \times 2008$</td>
<td>0.183*** (0.016)</td>
<td>0.206*** (0.016)</td>
<td>0.117*** (0.035)</td>
</tr>
</tbody>
</table>

Panel A1

| $N \times UC_{2004} \times 2006$ | -0.743*** (0.084) | -0.426*** (0.100) | -0.237*** (0.072) |
| $N \times UC_{2004} \times 2007$ | -0.462*** (0.087) | -0.267*** (0.103) | 0.133*** (0.070) |
| $N \times UC_{2004} \times 2008$ | -0.239*** (0.091) | -0.101 (0.107) | -0.008 (0.082) |

Panel A2

| $S \times comp^N \times 2006$ | -0.154*** (0.019) | -0.154*** (0.019) | -0.053*** (0.027) |
| $S \times comp^N \times 2007$ | -0.096*** (0.019) | -0.109*** (0.020) | -0.068*** (0.029) |
| $S \times comp^N \times 2008$ | -0.257*** (0.020) | -0.277*** (0.020) | -0.155*** (0.030) |

Panel B1

| $N \times comp^N \times 2006$ | -0.091*** (0.019) | -0.104*** (0.019) | -0.105*** (0.018) |
| $N \times comp^N \times 2007$ | -0.148*** (0.020) | -0.166*** (0.020) | -0.125*** (0.020) |
| $N \times comp^N \times 2008$ | -0.156*** (0.021) | -0.194*** (0.021) | -0.139*** (0.021) |

Panel B2

| $S \times comp^S \times 2006$ | 0.310*** (0.023) | 0.274*** (0.023) | 0.124*** (0.034) |
| $S \times comp^S \times 2007$ | 0.198*** (0.024) | 0.197*** (0.024) | 0.096*** (0.036) |
| $S \times comp^S \times 2008$ | 0.339*** (0.025) | 0.370*** (0.025) | 0.265*** (0.038) |

Panel C1

| $N \times comp^S \times 2006$ | 0.270*** (0.024) | 0.272*** (0.025) | 0.198*** (0.021) |
| $N \times comp^S \times 2007$ | 0.250*** (0.025) | 0.276*** (0.026) | 0.192*** (0.022) |
| $N \times comp^S \times 2008$ | 0.202*** (0.026) | 0.271*** (0.027) | 0.226*** (0.023) |

Panel C2

| $S \times 2006$ | -0.002 (0.005) | 0.003 (0.005) | 0.026*** (0.006) |
| $S \times 2007$ | 0.031*** (0.005) | 0.035*** (0.006) | 0.068*** (0.006) |
| $S \times 2008$ | 0.076*** (0.006) | 0.076*** (0.006) | 0.073*** (0.007) |

Panel D

<table>
<thead>
<tr>
<th>Hospital-year controls</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
</tr>
</thead>
</table>

Observations: 1786346 1710208 1504927
$R^2$: 0.095 0.093 0.095

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.
Panel labels in the right column (from A1 to C2) show the correspondence with the cells of Tables 1 and 2.
Table 11: Average relative effects (minutes)

<table>
<thead>
<tr>
<th>Reference hospital</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average relative effect in 2006</td>
<td>0.023</td>
<td>-0.184</td>
<td>0.623</td>
</tr>
<tr>
<td></td>
<td>(0.074)</td>
<td>(0.073)</td>
<td>(0.084)</td>
</tr>
<tr>
<td>Average relative effect in 2007</td>
<td>0.953</td>
<td>0.765</td>
<td>1.206</td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td>(0.080)</td>
<td>(0.109)</td>
</tr>
<tr>
<td>Average relative effect in 2008</td>
<td>1.965</td>
<td>1.744</td>
<td>1.644</td>
</tr>
<tr>
<td></td>
<td>(0.079)</td>
<td>(0.083)</td>
<td>(0.106)</td>
</tr>
</tbody>
</table>


*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, dropping small demand units *gzt*

<table>
<thead>
<tr>
<th>Min # of patients in <em>gzt</em></th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average relative effect in 2008 (minutes)</td>
<td>1.969</td>
<td>1.917</td>
<td>1.823</td>
<td>1.646</td>
<td>1.438</td>
<td>1.317</td>
</tr>
</tbody>
</table>


*Sample.* 1,153 hospitals in mainland France.

*Note.* Reference hospital: the largest in the *département*
### Table 13: Average relative effect in 2008 (minutes), by clinical department

<table>
<thead>
<tr>
<th>Activity share</th>
<th>Average relative effects</th>
<th>S.E.</th>
<th>Median time</th>
<th>Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthopedics</td>
<td>27.1%</td>
<td>0.636</td>
<td>(0.144)</td>
<td>22.5</td>
</tr>
<tr>
<td>ENT, Stomato.</td>
<td>13.0%</td>
<td>3.612</td>
<td>(0.216)</td>
<td>20.5</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>12.7%</td>
<td>1.915</td>
<td>(0.208)</td>
<td>23</td>
</tr>
<tr>
<td>Gastroenterology</td>
<td>11.8%</td>
<td>1.799</td>
<td>(0.214)</td>
<td>18.5</td>
</tr>
<tr>
<td>Gynaecology</td>
<td>8.5%</td>
<td>2.942</td>
<td>(0.232)</td>
<td>23</td>
</tr>
<tr>
<td>Dermatology</td>
<td>7.2%</td>
<td>3.494</td>
<td>(0.311)</td>
<td>20</td>
</tr>
<tr>
<td>Nephrology</td>
<td>7.0%</td>
<td>1.745</td>
<td>(0.313)</td>
<td>21</td>
</tr>
<tr>
<td>Circulatory syst.</td>
<td>5.1%</td>
<td>4.729</td>
<td>(0.399)</td>
<td>23.5</td>
</tr>
<tr>
<td>All</td>
<td>100.0%</td>
<td>1.965</td>
<td>(0.079)</td>
<td>22</td>
</tr>
</tbody>
</table>

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

**Sample.** 1,153 hospitals in mainland France.

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

### Table 14: Effect of competition in 2008 (minutes)

<table>
<thead>
<tr>
<th>Competition</th>
<th>SS</th>
<th>NS</th>
<th>SN</th>
<th>NN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of one s.d. of comp. index</td>
<td>2.263</td>
<td>1.470</td>
<td>-2.442</td>
<td>-1.650</td>
</tr>
<tr>
<td>Standard error</td>
<td>(0.160)</td>
<td>(0.194)</td>
<td>(0.193)</td>
<td>(0.232)</td>
</tr>
</tbody>
</table>

**Note.** Increasing exposure indicators 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 15: Allowing for heterogeneous marginal utilities of income

<table>
<thead>
<tr>
<th>Panel</th>
<th>Equation</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A1</td>
<td>$S \times UC_{2004} \times 2006$</td>
<td>0.083***</td>
<td>(0.017)</td>
<td></td>
</tr>
<tr>
<td>Panel A1</td>
<td>$S \times UC_{2004} \times 2007$</td>
<td>0.060***</td>
<td>(0.018)</td>
<td></td>
</tr>
<tr>
<td>Panel A1</td>
<td>$S \times UC_{2004} \times 2008$</td>
<td>0.150***</td>
<td>(0.018)</td>
<td></td>
</tr>
<tr>
<td>Panel A2</td>
<td>$N \times UC_{2004} \times 2006$</td>
<td>-0.338***</td>
<td>(0.102)</td>
<td></td>
</tr>
<tr>
<td>Panel A2</td>
<td>$N \times UC_{2004} \times 2007$</td>
<td>-0.181*</td>
<td>(0.105)</td>
<td></td>
</tr>
<tr>
<td>Panel A2</td>
<td>$N \times UC_{2004} \times 2008$</td>
<td>0.080</td>
<td>(0.110)</td>
<td></td>
</tr>
<tr>
<td>Panel B1</td>
<td>$S \times comp^N \times 2006$</td>
<td>-0.121***</td>
<td>(0.015)</td>
<td></td>
</tr>
<tr>
<td>Panel B1</td>
<td>$S \times comp^N \times 2007$</td>
<td>-0.091***</td>
<td>(0.016)</td>
<td></td>
</tr>
<tr>
<td>Panel B1</td>
<td>$S \times comp^N \times 2008$</td>
<td>-0.102***</td>
<td>(0.017)</td>
<td></td>
</tr>
<tr>
<td>Panel B2</td>
<td>$N \times comp^N \times 2006$</td>
<td>-0.054***</td>
<td>(0.014)</td>
<td></td>
</tr>
<tr>
<td>Panel B2</td>
<td>$N \times comp^N \times 2007$</td>
<td>-0.134***</td>
<td>(0.015)</td>
<td></td>
</tr>
<tr>
<td>Panel B2</td>
<td>$N \times comp^N \times 2008$</td>
<td>-0.094***</td>
<td>(0.017)</td>
<td></td>
</tr>
<tr>
<td>Panel C1</td>
<td>$S \times comp^2 \times 2006$</td>
<td>0.416***</td>
<td>(0.040)</td>
<td></td>
</tr>
<tr>
<td>Panel C1</td>
<td>$S \times comp^2 \times 2007$</td>
<td>0.407***</td>
<td>(0.041)</td>
<td></td>
</tr>
<tr>
<td>Panel C1</td>
<td>$S \times comp^2 \times 2008$</td>
<td>0.572***</td>
<td>(0.043)</td>
<td></td>
</tr>
<tr>
<td>Panel C2</td>
<td>$N \times comp^2 \times 2006$</td>
<td>0.246***</td>
<td>(0.028)</td>
<td></td>
</tr>
<tr>
<td>Panel C2</td>
<td>$N \times comp^2 \times 2007$</td>
<td>0.363***</td>
<td>(0.029)</td>
<td></td>
</tr>
<tr>
<td>Panel C2</td>
<td>$N \times comp^2 \times 2008$</td>
<td>0.325***</td>
<td>(0.030)</td>
<td></td>
</tr>
<tr>
<td>Panel E1</td>
<td>Pri-owned × 2006</td>
<td>0.079***</td>
<td>(0.010)</td>
<td></td>
</tr>
<tr>
<td>Panel E1</td>
<td>Pri-owned × 2007</td>
<td>0.054***</td>
<td>(0.010)</td>
<td></td>
</tr>
<tr>
<td>Panel E1</td>
<td>Pri-owned × 2008</td>
<td>0.041***</td>
<td>(0.010)</td>
<td></td>
</tr>
<tr>
<td>Panel E2</td>
<td>Gov-owned × 2006</td>
<td>-0.066***</td>
<td>(0.011)</td>
<td></td>
</tr>
<tr>
<td>Panel E2</td>
<td>Gov-owned × 2007</td>
<td>-0.019*</td>
<td>(0.011)</td>
<td></td>
</tr>
<tr>
<td>Panel E2</td>
<td>Gov-owned × 2008</td>
<td>-0.001</td>
<td>(0.011)</td>
<td></td>
</tr>
<tr>
<td>Panel F</td>
<td>Gov-owned × debt ratio$_{2004} \times 2006$</td>
<td>-0.028**</td>
<td>(0.013)</td>
<td></td>
</tr>
<tr>
<td>Panel F</td>
<td>Gov-owned × debt ratio$_{2004} \times 2007$</td>
<td>0.020</td>
<td>(0.014)</td>
<td></td>
</tr>
<tr>
<td>Panel F</td>
<td>Gov-owned × debt ratio$_{2004} \times 2008$</td>
<td>0.053***</td>
<td>(0.014)</td>
<td></td>
</tr>
<tr>
<td>Hospital-year controls</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
Panel labels in the right column (from A1 to C2) show the correspondence with the cells of Tables 1 and 2.
Table 16: Effect of marginal utility of income in 2008 (minutes)

<table>
<thead>
<tr>
<th>Effect of one s.d. of debt ratio</th>
<th>0.377</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard error</td>
<td>(0.056)</td>
</tr>
</tbody>
</table>

*Note.* Increasing the debt ratio by one standard deviation


*Sample.* 1,153 hospitals in mainland France.

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

Standard errors are computed by bootstrap.
Figures

Figure 4: Evolution of the number of surgery admissions (Years 2005 to 2008)