COMPETITION BETWEEN HOSPITALS

Does it Affect Quality of Care?

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COMPETITION BETWEEN HOSPITALS

Does it Affect Quality of Care?

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Daniel COHEN
Head of the CEPREMAP

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Introduction

Brigitte Dormont

Nowadays, all developed countries are trying to improve efficiency in hospital care through implementation of prospective payment systems based on Diagnosis Related Groups (DRGs). Following the example set by Medicare beginning in 1983, other payers in the USA have adopted DRG based payments for inpatient care. European countries first used a global budget system to contain hospital costs during the 1980s, before turning to prospective payment per DRG at the beginning of the 2000s.

The goal of a prospective payment system is to encourage efficiency in care delivery. Paying hospitals a fixed price per stay in a given DRG provides a powerful incentive for managers to minimize costs. Indeed, hospitals are assumed to keep the rent earned when their costs are lower than the fixed price. Conversely, they risk running operating losses if their costs are above DRG payment rates.

Shleifer's yardstick competition model provides the theoretical foundation for prospective payments. This model is based on the assumptions of homogeneity of hospitals, homogeneity of patients for the same pathology, and fixed quality of care. Any deviation in cost for a stay in a given DRG is supposed to stem from inefficiency.

Because it puts strong pressure on hospitals to lower their costs, wide implementation of payment per DRG raises serious concerns about quality of care. Indeed, if quality of care is costly, hospitals are discouraged from providing above-average quality because they risk incurring costs that exceed the DRG payment rate.

How can the search for hospital efficiency be prevented from jeopardizing quality of care? Several non mutually exclusive solutions can be considered: enforce the required level of quality through administrative controls; introduce some cost sharing[1] to alleviate the pressure resulting from fixed payments; introduce explicit financial incentives such as pay-for-performance to promote quality of care; encourage quality competition among hospitals.

All of these strategies have been implemented by developed countries, in varying degrees. They all secure a minimal level of quality through administrative controls, and implement some cost-sharing. As part of the Affordable Care Act, the US government has introduced pay-for-performance in all hospitals paid by Medicare, and currently pay-for-performance programs are being adopted throughout developed countries. In many OECD countries, policies encouraging competition among hospitals have been introduced as a way of improving quality. The purpose of this conference volume is to examine the potential impact on quality of care of prospective payment systems based on DRGs, and to investigate the suitability of promoting quality competition.

To highlight the potential advantages of quality competition, it is important to describe the shortcomings of (i) administrative controls, (ii) cost sharing and (iii) pay-for-performance.

(i) Administrative controls are necessary, but they refer by definition to a given level of observable quality. Hence, they generally serve to secure a minimal level of quality and they cannot serve to promote quality improvements.

(ii) The idea behind cost sharing is that differences in efficiency are not the only source of cost heterogeneity between hospitals. There are other sources of cost heterogeneity, many of which are not observable by the regulator. If a hospital that provides high quality of care is fully efficient, it cannot achieve further savings through efficiency gains. Hence, careless implementation of fixed payments per DRG, which puts hospitals under

1. Cost sharing combines prospective and retrospective payments: The payment per stay is a weighted average of the lump-sum and of the actual cost of treatment.

pressure to lower costs, might create undesirable incentives for lowering care quality, or discriminating among patients or selecting patients. To design a payment system that creates virtuous incentives for enhancing hospital efficiency, many theoretical papers have improved the basic model by lifting assumptions relative to patient and hospital homogeneity, and by allowing for an endogenous[1] level of care quality (Chalkley and Malcomson, 2000). Using various theoretical frameworks, these papers show that social welfare can be improved through a mixed payment system that combines a fixed price with partial reimbursement of the actual cost of treatment. To deal with unobserved sources of heterogeneity in costs, the regulator can construct a menu of contracts that combine a lump sum transfer with partial reimbursement of actual costs. When the hospital chooses a contract, it reveals its unobserved cost component to the regulator (Laffont and Tirole, 1993). Another strategy is to use econometrics to evaluate unobservable sources of cost heterogeneity in order to design payments that allow for differences in quality, while still providing incentives for more efficiency (Dormont, 2014).

In practice however, implementation of a mixed payment system is not straightforward: The proportions of the lump sum and the actual cost can be defined very differently, depending on the theoretical model used, its main hypotheses, and its parameterization. Moreover, the definition of the payment formula often relies on unobservable variables or functions. In addition, cost sharing is only a second best solution and comes down to paying for a share of moral hazard, i.e. for avoidable costs.

(iii) Pay-for-performance (P4P) schemes consist of additional payments based on meeting targets linked to quality indicators. A first experiment was launched in the USA in 2003; it was followed by a nationwide pay-for-performance scheme applied since 2013. New forms of P4P, named "Best

1. This means that the level of quality is chosen by the hospital, whereas the seminal model of yardstick competition assumes that the level of quality is given.

practice tariffs" have been implemented in the United Kingdom since 2011. In the same way, measures can be taken to discourage inappropriately early discharges, which otherwise tend to develop because payments per DRG provide incentives to shorten stays. So, penalties have been introduced in the US under the Hospital Readmission Program, and in the UK there are penalties for emergency readmissions within 30 days of discharge following an elective admission (KCE, 2013).

There is much debate on the potential adverse effects of financial rewards based on quality indicators. First, quality is multidimensional, and some dimensions are difficult to observe and cannot be summarized in a quantitative indicator. Hence, P4P payments are always defined for a limited selection of indicators, leaving no financial incentives for many aspects of care quality, especially dimensions that are not easy to quantify with a score. In a multitask interpretation, care providers might reduce their efforts to improve quality for activities that are not linked to incentives (empirical evidence of such behavior has been found by Campbell *et al.*, 2009). Second, rewards can be counterproductive because they undermine intrinsic motivation. As argued by Bénabou and Tirole (2003), "performance incentives offered by an informed principal [...] can adversely impact an agent's [...] perception of the task, or of his own abilities. Incentives are then only weak reinforcers in the short run and negative reinforcers in the long run."

These arguments show that theory does not make it possible to predict if pay-for-performance is likely to improve care quality or not. Hence, it is of major importance to see how it works in practice. Evaluations of the effectiveness of P4P programs at hospitals have found contradictory results. In the US, an experiment including a control group was carried out in Medicare and Medicaid hospital services. Initially, hospitals with P4P improved their performance more than the control group. However, after five years, the two groups' scores were identical, with no improvement in risk-adjusted 30-day mortality (Werner *et al.*, 2011; Jha *et al.*, 2012). In contrast, the introduction of pay-for-performance in all NHS hospitals in one region of England was associated with a clinically significant reduction in mortality (Sutton *et al.*, 2012). In fact, the P4P programs were quite different in the two experiments: The UK program had larger bonuses and a greater investment by hospitals in quality improvement.

Contradictory results, together with the risk of detracting from intrinsic motivations, suggest that P4P should remain a minor part of care providers' payments. Further research is needed on the design of pay-for-performance programs (magnitudes of financial incentives, target definitions, individual or practice level incentives) in order to understand how practical implementation influences their effects.

To sum up, administrative controls, cost sharing and pay-for-performance programs have some drawbacks and are clearly not sufficient to avoid the potential deleterious impact on care quality of DRG-based prospective payments. This is why it is important to consider the complementary strategy which consists of encouraging competition among hospitals to stimulate improvements in quality.

Is hospital competition good for care quality? In theory, there is a marked distinction between the case where prices are set endogenously by hospitals, and the case where they are fixed exogenously by a regulator (Gaynor and Town, 2012). When prices and quality of care are decided on endogenously by hospitals, they "may react to increased competition [...] by trading off prices for quality, attracting higher volume but producing lower quality output" (Cooper and McGuire, 2014). In other words, when prices are not fixed, competition is not necessarily counterproductive, but it can be. In contrast, when prices are fixed exogenously, competition should lead to better quality: In this case, hospitals can increase their revenue by treating more patients, and they can compete for patients only by improving the quality of care.

There is a growing literature in the US on the impact of hospital competition on quality. As expected, findings are mixed for studies on hospitals that set their own prices. On the other hand, several studies show a positive effect of fixed price competition on clinical outcomes (Kessler and McClellan, 2000). These studies are performed on inpatient care delivered to Medicare beneficiaries, for whom there is fixed price competition because Medicare pays hospitals in the form of DRG-based lump-sums. Several papers on the National Health Service in the UK have reinforced the idea that the impact of hospital competition on quality strictly depends on whether prices are fixed or not. At a time when prices were determined endogenously, Propper *et al.* (2004) found that more intense competition was associated with higher death rates within the 30 days following an Acute Myocardial Infarction (AMI). After reforms that encouraged patient choice and introduced DRG-based fixed prices in the English NHS, Cooper *et al.* (2011) showed that hospital quality-measured by 30 day AMI mortality-improved more quickly in more competitive areas. After a review of the impact of competition on the hospital sector, Cooper and McGuire (2014) conclude that there is robust empirical evidence that, under exogenously fixed prices, increased competition can lead to improved quality.

The purpose of this conference volume is to examine the theoretical and empirical conditions that can lead to a positive impact of fixed price competition on the quality of hospital care. We address the following questions: Does more intense competition between hospitals under fixed prices always result in higher quality of care? Do hospital ownership or/and objectives matter? Is the impact of more competition on quality the same for different diseases? What is the right scope for competition? Is it appropriate to introduce competition between hospitals with different mandates?

The empirical literature on these issues generally uses data from the USA or England[1]. This volume also considers empirical results obtained on French data. Actually, the US, the UK and France have rather different

1. Most empirical results on hospital competition and quality of care in the UK are based on data limited to England.

healthcare systems. However, hospital payment systems based on Diagnosis Related Groups are in place in these three countries. One difference between the American, British and French systems stems from the financing —or coverage—of health care: health care is provided in the UK by a public agency (the National Health Service) financed through general taxation, whereas in France social insurance provides universal coverage, with supplementary coverage provided by private insurance. In the USA, health care financing is managed by distinct organizations: One third of Americans is covered by government health care programs (notably Medicare and Medicaid); the other two thirds being covered by private insurance provided by employers or subscribed to on an individual basis.

The share of inpatient care provided by public or private hospitals differs widely between the three countries. Whereas most hospital services are delivered by public providers in the UK, health care facilities in the US are mainly private: 51% are private not-for-profit hospitals, 18% for-profit hospitals and 18% state and local government community hospitals (KCE, 2013). In France, hospital care is mostly delivered by public hospitals (66% of acute care beds), but private-for-profit hospitals have a considerable importance (25% of acute care beds and 46% of surgical beds). Private not-for-profit hospitals provide only a small share of hospital care (9% of acute care beds).

Starting in 1983, the Medicare program in the US was a pioneer with the introduction of a prospective payment per DRG for Medicare inpatients. European countries followed much later: 2003-2004 for England, with a system named "Payment by Results" (KCE, 2013); 2004 for France, with a system named "Tarification à l'activité". Currently, the way payments per DRG are implemented is quite similar across countries: DRG classifications are similar; there are additional payments for research, training and medical education; there are retrospective reimbursements for high cost devices and high cost drugs, and for exceptionally long stays. However, there are some differences between the US, England and France as regards the homogeneity of payment rates within and between hospitals. Whereas payment rates are the same for all patients in all public facilities in England, American hospitals receive different payments for Medicare patients and for those covered by a private insurer. Medicare payments are defined as fixed prices per DRG, while prices for private insurers are generally set by negotiation between the hospital and the private payer. Currently, private payment rates are higher than Medicare's: as a result privately insured patients alleviate the pressure on costs induced by fixed prices per DRG. It is even possible for hospitals to shift costs by setting higher rates for private payers to offset reductions in Medicare rates. However, results on years 1995-2009 show no evidence of cost-shifting (White, 2013). In France, payment rates set by the social insurance administration are the same for all patients at a given hospital, but rates are different for public and private hospitals. Hence there is no yardstick competition between public and private hospitals, even though all hospitals have incentives to attract more patients.

Despite these differences between countries, it is possible to define a common theoretical framework to examine the potential impact of prospective payments per DRG on the quality of hospital care. Moreover, empirical results obtained on US data can be considered relevant for other countries.

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The purpose of this volume is to bring together relevant theoretical and empirical results regarding the impact of promoting quality competition between hospitals.

In the first chapter, Brekke, Gravelle, Siciliani and Straume review the theoretical literature on competition and quality, a body of literature to which they themselves have largely contributed. They examine the conditions under which fixed price competition can be expected to have a positive impact on quality. They show that increasing competition between hospitals under fixed prices does not always result in higher quality of care. The existence of a positive or a negative impact of competition on quality depends on: the degree of hospital altruism, its profit constraints, its cost structure, the degree of specialization, as well as the existence of soft budgets and sluggish demand adjustments. Their model considers the cost and price of treatment for a single pathology, with a monodimensional formalization of quality q. Quality and quantity (number of patients treated) are costly. The patients are assumed to observe quality perfectly, and demand is assumed to react positively to quality improvements. Assuming that competition increases the responsiveness of demand to quality, the authors show that if the price-cost margin is positive, more competition increases the profitability of a marginal increase in quality. This is the basic argument put forward in the literature on the impact of fixed price competition on quality. Conversely, with a negative price-cost margin, the predicted impact of competition on quality is negative. In particular, intrinsic motivation and altruism may induce providers to work at negative profit margins. In this case, increased competition can lead to lower quality.

Next, Brekke *et al.* allow for strategic interactions between hospitals in their model. They show that hospitals' reaction to rivals' improvement in quality depends on whether the marginal cost of treatment is increasing or decreasing with respect to the number of patients and with respect to quality. If quality competition is promoted through dissemination of comparative information on quality, this can increase the level of demand. In that case, if the marginal cost of treatment increases with quantity, the positive effect of competition on quality is dampened. Actually, competition can be promoted through two channels: publication of comparative information on quality or an increase in the number of competing hospitals. Brekke *et al.* show that these two policies might have different impacts on quality. Finally, they show that the existence of soft budgets does not really alter predictions of the effect of competition on quality.

In chapter 2, Dormont and Milcent address the issue of the scope of competition. In France, public and private hospitals are subject to different mandates that influence their size and composition of activity, whereas prospective payments lead to budgets that are linear in the number of stays in each DRG. The implicit assumption underlying such payments is that there are no scale or scope economies. Actually, some hospitals receive an additional annual budget for activities such as teaching, research, palliative care, geriatry, emergency care, or for having a high proportion of low income patients. But payment for stays in acute care is designed as if hospital size and composition of activity had no influence on cost per stay.

The starting point of Dormont and Milcent is that crude productivity measures indicate that public and private nonprofit hospitals are more costly than private-for-profit hospitals in France. Their work shows that the productivity gap is due to the mandate of public hospitals: They cannot specialize, and they cannot turn down patients. Once patient characteristics and production composition are explicitly taken into account, public hospitals are more efficient and the ranking is reversed. Lower productivity in public hospitals is explained by oversized establishments and by patient and production characteristics, but not by inefficiency in the short to medium term. Hence, reinforcing competition between public and private hospitals through a convergence of payment rates would provide incentives for public hospitals to change the composition of the care services they supply, a change that might be contradictory to their mandate.

Most theoretical models consider a single pathology, whereas in reality hospitals produce care services for patients affected by different diseases. Hospital care is not a homogenous product, and profitability, as well as sensitivity of demand to quality, can vary across diseases. What is the impact of more competition on care quality for different diseases? In chapter 3, Colla, Bynum, Austin and Skinner use US Medicare data to study how fixed-price competition affects quality of care for heart attacks, hip and knee replacements, and treatment of dementia. As stated in

Chapter 1, theoretical models predict that when prices are fixed, hospitals will compete for patients by improving quality for those diseases with the highest profitability and the highest demand elasticity. Colla *et al.* consider several diseases: treatment of Acute Myocardial Infarction (AMI), for which the elasticity of demand is low because ambulances take patients to the closest hospital; hip and knee replacements, for which demand elasticity with respect to quality is high, since surgery is scheduled in advance, which allows the patient to make an informed choice of hospital; and care for dementia, whose profitability is low or negative. In principle, we should expect a small or negligible effect of competition on quality for AMI patients, a sizeable positive association between quality and competition for hip and knee replacements, and a negative or null association for dementia.

For dementia patients, Colla *et al.* find that, according to several measures, poor clinical care is associated with competition, a finding that accords with theoretical predictions. For other diseases empirical evidence does not entirely support theoretical predictions. While the influence of competition on several quality indicators was sensitive to model specification for heart attack, hip and knee replacements showed no consistent association. Another important result is that the correlation coefficient between risk-adjusted AMI mortality and risk-adjusted hip or knee complications is zero: AMI quality cannot be considered a good summary marker for hospital quality, contrary to what is often argued in the empirical literature devoted to hospital competition and quality.

In chapter 4, Gobillon and Milcent study the effect on hospital quality of the prospective payment system gradually introduced in France between 2004 and 2008, which they interpret as a pro-competition reform. They evaluate for different types of hospitals the impact on AMI mortality of competition incentives engendered by the reform. Estimates are based on an exhaustive dataset of heart attack patients over the 1999 to 2011 period. They provide evidence that patients admitted to private nonprofit hospitals are less likely to die after the reform in markets that are not very concentrated, but they do not find clear-cut impact of competition on mortality for public or for-profit hospitals. It should be noted that for-profit hospitals were already competing with each other before the introduction of the DRG based payment system.

The last section of the volume contains comments by Pedro Pita Barros and Jon Magnussen. They point out that the chapters examine the final stage of a more complete game, in which prices are determined by regulation in an earlier stage and quality decisions follow. For consistency, the implicit larger sequential game requires that quality can change more often than regulated prices, which might or might not be true, depending on the dimension of quality that is considered.

The paper by Brekke *et al.* provides an answer to the question of what conditions must be fulfilled for competition to have a positive impact on quality. Increasing competition between hospitals under fixed prices does not always lead to higher quality. The overall impact is ambiguous, but Brekke *et al.*s' clearly identify the direction of different forces. Pita Barros and Magnussen remark that the role of information asymmetries, uncertainty, adverse selection and moral hazard are ignored in chapter 1, whereas it is important to know if these factors affect results. Moreover, two other features deserve attention in future research: First, in systems with a National Health Service, the regulator can take advantage of competition between public and private hospitals, and use public hospitals and their objectives to intervene in the hospital market; second, quality is supposed to be product specific, whereas more general treatment would examine provider-wide, across-product quality. According to Pita Barros and Magnussen, chapter 2 challenges current views concerning the superiority of private management. It also questions the pertinence of using uniform regulated prices under the presence of economies of scale and scope, because public hospitals are mandated to accept all patients and to serve all medical needs. It would be interesting to extend the analysis to input-prices.

Commenting on chapter 3, Pita Barros and Magnussen call for information on how quality affects cost of treatment in each type of procedure and across hospitals. They criticize the use of the LOCI index to measure the intensity of competition. Indeed, this index was constructed for price competition, but prices are fixed in the empirical framework of chapter 3. Pita Barros and Magnussen then propose an adaptation of the LOCI index to quality competition under fixed prices. They conclude by asking if the results of chapter 3 provide sufficient understanding of how competition impacts quality to decide whether more or less competition is desirable. Their answer is "Not yet", but that "this paper starts to walk the path leading to the answer."

Pita Barros and Magnussen say that Gobillon and Milcent's analysis is a welcome addition to the literature on hospital competition, where there are few studies on Europe. However, the use of AMI quality as "a general marker for hospital quality deserves to be discussed more thoroughly." (we have seen that this approach is challenged by the results of Colla *et al.* in chapter 3). In addition, the results of Gobillon and Milcent are rather disappointing for people who believe in the merits of competition: they show an effect of market concentration on the quality of private non-profit hospitals, but no effect on the quality of public or private for-profit hospitals. More analysis should be devoted in future research to evaluating the influence of care quality on the demand for care, and to evaluating how costs vary with quality in France.

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Should we encourage quality competition among hospitals in order to improve quality of care? The effects of increased competition depend on many determinants that have been examined in this volume, and they can vary across diseases. The authors present valuable evidence for a limited number of conditions. To further enlighten the debate on the effects of hospital competition, it is essential to collect more accurate data for each major DRG on costs and care quality at the hospital-stay level.

One condition required for competition to induce better quality is connected to marginal profitability. Hence, regulated prices influence the impact of competition on quality. As stated by Pita Barros and Magnussen, it is necessary to consider the complete game, including the determination of regulated prices. Moreover, a hospital's cost function is unlikely to be separable between diseases, and reputation exists for a hospital as a whole and not only for separate diseases.

All of the studies presented here focus on supply side, but a key assumption in hospital competition models is that the demand for care is sensitive to quality. Actually, not much is known about the drivers of hospital choice by patients or referring doctors. Quality has several dimensions, and the information provided to patients can be detailed in some dimensions and less complete on others. As a result, patients may focus on a dimension of quality that is not very important for health outcomes (Huesmann and Mimray, 2015). What is the impact of more competition in such a case? More research is needed on the demand side.

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1
Hospital Quality Competition: A Review of the Theoretical Literature

Kurt R. Brekke, Hugh Gravelle, Luigi Siciliani
and Odd Rune Straume

ABSTRACT

Policies to promote competition amongst hospitals have been introduced in many countries as a means of improving quality. The rationale is that when hospitals face fixed prices they can only attract additional patients by increasing quality and intensified competition increases the effect of quality on demand. We review theoretical models of hospital competition to examine this argument and explain how the effect of competition on quality is sensitive to the degree of hospital altruism, profit constraints, cost structures, the degree of specialisation, soft budgets, and sluggish demand adjustments.

INTRODUCTION

Policymakers in several OECD countries are increasingly keen to introduce or encourage competition among hospitals in the attempt to improve quality of care to patients. The intuitive idea is that if hospitals are paid a fixed (regulated) price for each patient treated, then hospitals will have to compete on quality to attract patients. The policy is often the subject of intense political and academic debate.[1]

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1. This is certainly the case in England (see Bloom *et al*., 2011a and b; Pollock *et al*., 2011; Bevan and Skellern, 2011; OHE, 2012).

Our primary objective in this chapter is to summarise a selection of theoretical models which highlight the mechanisms through which competition may or may not increase quality. We show how the predicted effect of competition on quality is sensitive to assumptions about the form of competition policies and the specific features of the hospital sector such as altruistic motives, profit constraints, cost structures, degree of specialisation, soft budgets and sluggish demand adjustments. We also briefly discuss optimal price regulation and the effect of competition on quality when prices are not regulated.

Following the literature we model hospitals as a single decision maker. In reality, hospitals are complex organisations with several decision makers, including managers and doctors, where arguably doctors give more weight to patient benefit compared to managers who will be concerned also with costs and overall profitability. The hospital's objective function used below is a reduced form. The quality chosen by the hospital can be interpreted as the outcome of an agreement reached by the key decision makers within the hospital. We start by providing a general model of hospital quality competition which allows for both altruistic preferences and profit motives. We also allow for profit constraints to capture key institutional features of non-profit and public hospitals.

We argue that more competition affects both the responsiveness of demand to quality and the level of demand faced by providers. If hospitals seek to maximise profit (ie are non-altruistic) and if the marginal cost of output is constant with respect to output and quality, then more competition increases quality if the price-cost margin is positive. Constraints on profit distribution generally diminishes the potential positive effect of competition on quality since the provider is less responsive to financial incentives.

If the marginal cost of treatment is increasing in output or in quality, then the positive effect of competition on quality due to a higher demand responsiveness to quality can be reinforced (or dampened) if competition leads also to lower (or higher) demand for each firm. For example, if greater competition arises from the entry of an additional provider, this typically involves less demand for each hospital. In contrast, if greater competition arises from potential patients being offered a bigger choice amongst existing providers, this could increase overall demand, with increases at higher quality providers, reductions at lower quality providers, and higher demand overall as some potential patients decide to be treated.

We discuss different possible micro-founded specifications of the demand functions, including Hotelling and Salop spatial frameworks where patients differ in the distance to the providers. In their simplest formulations with fixed total demand, lower transportation costs (ie more competition) imply a more responsive demand but have no effect on the demand of each hospital in equilibrium. If the Hotelling model is augmented with a monopolistic segment, then lower transportation costs will imply both more responsive demand and higher overall demand. In a Salop model a larger number of providers (more competition) implies that demand responsiveness to quality is unchanged (since competition is local), but each hospital faces a lower demand.

The presence of altruistic preference alters and potentially reverses the positive effect of competition on quality. In the presence of non-constant marginal cost of treatment, altruistic providers may operate at a negative profit margin and so potential increases in demand due to an increase in competition may lead them to reduce quality.

If hospitals can specialise (for example choose their location on the Hotelling line), they may respond to increased competition by further product differentiation to partially relax competition on quality.

The presence of sluggish demand adjustments implies that demand and quality may vary over time. In the presence of increasing marginal cost of treatments, quality and demand may move in opposite directions over time while converging to the steady state. The opposite holds in the presence of altruistic preferences and constant marginal cost: quality and demand move in the same direction over time. We also compare quality levels under different dynamic solution concepts which correspond to environments with different degree of competition. We show that the presence of increasing marginal cost implies that quality is lower in the more competitive environment. The opposite holds in the presence of altruistic preferences.

We conclude the review by examining the effect of competition in markets where hospitals, rather than regulators, set prices. With endogenous prices, the requirements for competition to increase quality are more stringent than with fixed prices. If competition reduces prices and thereby reduces the price-cost margin this will reduce the marginal incentive to invest in quality.[1]

A model of Hospital Behaviour

In this Section, we outline a simple hospital model of quality choice and use it to make predictions about the effect of a policy which makes demand more responsive to quality. This specification brings out the importance of assumptions about the cost structure. We also show that assumptions about the hospital objectives are crucial and examine the implications of different specification of altruistic preferences. In the next section, we consider markets with several providers where demand for one provider depends on the quality of other providers. We identify the conditions under which qualities are strategic complements or substitutes (ie whether a provider responds to an increase in rival's quality by increasing or reducing

1. Our review of the literature covers a number of recent articles not included in Gaynor (2006), Gaynor and Town (2011) and Katz (2013). Moreover, it provides a much more detailed discussion and presentation of the theoretical models compared to Brekke *et al*. (2014).

quality). We then discuss the Hotelling and Salop specifications, which are common in the literature.[1]

The profit of the hospital is

$$\pi(q) = T + pD(q,\theta) - C(D(q,\theta),q) \tag{1}$$

where q is the quality of the hospital, p is the fixed price, $T \geq 0$ is a lump-sum transfer, $D(.)$ is demand,[2] θ is a competition parameter (discussed in more detail below). $C(.)$ is the cost function and depends both on the number of patients treated and quality (with $C_D > 0$, $C_q > 0$, and $C_{qq} > 0$). Both quality and quantity are costly. We assume that the hospital treats all patients who demand care: demand equals supply.[3]

We leave the specification of the cost function general with $C_{DD} \gtreqless 0$, $C_{qD} \gtreqless 0$. This specification encompasses several intuitive special cases. In the presence of diseconomies of scale, the marginal cost of treatment is increasing ($C_{DD} > 0$). This assumption will hold at least for larger hospitals: the empirical evidence shows that diseconomies of scale appear above 250-300 beds in the hospital sector (see, e.g., Aletras, 1999; Folland *et al.*, 2004, for literature surveys). The closer a hospitals' production is to capacity, the more costly it becomes to treat one more

1. The model presented in this Section is adapted from Brekke *et al.* (2011, 2012) who allow for profit constraints, altruistic preferences and non-constant marginal cost of treatment and quality. For a model where hospitals compete on waiting times rather than quality see Brekke *et al.* (2008).
2. Several empirical studies suggest that demand responds to variations in quality (see for example Beckert *et al.*, 2012, and Gaynor *et al.*, 2011 for the English National Health Service; and Luft *et al.*, 1990; Hodgkin, 1996; Tay, 2003; Ho, 2006; Howard, 2005 for the US).
3. We assume that quality can be perfectly observed by the patients. For models where quality is observed with some noise see Gravelle and Sivey (2010) and Montefiori (2005). For a model where patients face switching costs see Gravelle and Masiero (2000). For a model with gatekeeping doctors see Brekke *et al.* (2007). For a model which allows for excess demand, see Chalkley and Malcomson (1998b).

patient. The utilisation of capacity in hospitals seems to vary across countries with different health care systems. In more regulated (public) health care systems (e.g., the UK, the Scandinavian countries, Spain, Italy), there is typically excess demand (waiting), suggesting that hospitals operate at a steeper part of the marginal cost curve. However, in less regulated systems (e.g., the US, Germany, France), there is often excess supply, suggesting relatively constant hospital marginal costs. Small hospitals may instead be characterised by economies of scale ($C_{DD} < 0$).

We also allow for both cost substitutability ($C_{Dq} > 0$) and cost complementarity ($C_{Dq} < 0$) between quality and output. The assumption of cost substitutability holds if the marginal cost of treating a patient increases with quality. This is a plausible assumption. It is for example consistent with constant returns to scale with respect to the number of patients treated when the cost per patient is increasing in the quality provided ($C(.) = c(q)D$, with $C_{Dq} = c'(q) > 0$). On the other hand, treating more patients might in itself improve quality due to "learning-by-doing" effects. If sufficiently strong, it is possible that quality and output are cost complements ($C_{Dq} < 0$). As shown below, the cost structure has implications for predicting the effect of competition on quality.

We assume that providers care directly about quality, not just because of its effect on profit. This may be because they are altruistic and care about the effect of quality on patients. Or they may have reputational concerns or are intrinsically motivated. We denote the direct provider benefit from quality as $b(q)$, with $b_q(q) > 0$ and $b_{qq}(q) \leq 0$. We explore the implications of different specifications, for example with b depending on output as well, in the next subsection. Providers may also incur effort or non-monetary costs of providing quality, which we denote $\varphi(q)$, with $\varphi_q(q) > 0$ and $\varphi_{qq}(q) > 0$.

The hospital's objective function is

$$V(q) = (1 - \delta)\pi(q) + b(q) - \varphi(q) \tag{2}$$

where $\delta \in [0,1)$ is a parameter arising from constraints on the amount or distribution of profit. Some hospitals are public, some are non-profit and others are for-profit. The parameter δ captures the legal status of the provider and the type and tightness of any profit constraints. With for-profit hospitals with no intrinsic quality concerns or non-monetary effort costs, we could assume $\delta = 0$. With non-profit or public hospitals we could have $\delta > 0$. Non-profit hospitals cannot distribute profits in cash but have to spend any positive net revenues on perquisites. If owners prefer compensation in cash over compensation in perquisites, a monetary net surplus (profit) has lower value for the owner of a non-profit firm than for the owner of a for-profit firm, i.e., $\delta > 0$.[1]

The optimal level of quality q^* satisfies the first order condition

$$(1-\delta)\pi_q(q^*,\theta) + b_q(q^*) - \varphi_q(q^*) = 0 \tag{3}$$

where $$\pi_q \equiv [p - C_D(q^*,\theta)] \cdot D_q(q^*,\theta) - C_q(q^*,\theta)$$

We assume that the problem is well behaved and the second order condition is satisfied: $V_{qq} < 0$.

At the optimal quality the marginal monetary and non-monetary benefit is equal to the marginal monetary and non-monetary cost. The marginal non-monetary benefit is given by the altruistic component to provide quality. The marginal monetary benefit consists of the revenues. The difference in the monetary marginal benefit and cost gives the marginal profit, which is reduced in the presence of profit constraints.

The incentive to increase quality is stronger when the profit margin (price minus the marginal cost of output) is larger. In many hospital payment systems, a DRG-type pricing scheme is adopted with the regulated price being set at the average cost. This in turn implies that the profit

1. This type of modelling is used by Brekke *et al*. (2012), Glaeser and Shleifer (2001) and Ghatak and Mueller (2011).

margin (defined as the price minus marginal cost) is larger for procedures with large fixed costs and low marginal costs. The profit margin is positive for hospitals operating at volumes where the marginal cost is constant or decreasing. A hospital with increasing marginal cost and a sufficiently high volume, may be operating at a negative profit margin. The profit margin is greater in those countries where the regulated price includes investment/capital costs. Some countries, like Norway, set the fixed price as a proportion (40-60%) of the average cost. In such case the profit margin may be negative.

The effect of competition θ on quality is

$$\frac{\partial q^*}{\partial \theta} = \frac{-V_{q\theta}}{V_{qq}} = \frac{(1-\delta)\pi_{q\theta}}{-(1-\delta)\pi_{qq} - b_{qq} + \varphi_{qq}} \tag{4}$$

where

$$\pi_{q\theta} = (p - C_D)D_{q\theta} - \left(C_{DD}D_q + C_{Dq}\right)D_\theta \tag{5}$$

Since the denominator in (4) is negative (by the second order condition), the sign of $\partial q^* / \partial \theta$ depends on the sign of $\pi_{q\theta}$. If competition increases the responsiveness of demand, then $D_{q\theta} > 0$. Assuming that the price-cost margin is positive, the first term is positive and so makes it more likely that more competition will increase the profitability of a marginal increase in quality. This is the basic argument in the literature for competition to increase quality.

Competition will also have an effect on the overall demand, which is capturedby D_θ.[1] If the marginal cost of treating an extra patient is not affected by quality ($C_{Dq} = 0$) and the marginal cost is constant ($C_{DD} = 0$), then this effect is irrelevant. Otherwise, competition will also affect the profitability of quality investment through the effect on overall demand.

1. We could have $D_{q\theta}(q^*, \theta) > 0$ with $D_\theta(q^*, \theta) = 0$, so that the demand function pivots through the point $(D(q^*, \theta), q^*)$, but this cannot hold for all q.

As an example, suppose that the marginal cost of treatment is increasing ($C_{DD} > 0$) or that cost of treatment per patient increases with quality ($C_{Dq} > 0$). Assume also that "competition" implies that an additional hospital enters a given market, then it would seem natural to assume that $D_\theta < 0$: for a given catchment area population, a hospital faces a lower demand when another firm enters the market. Then the second term in (5) is also positive, and the positive effect of competition on quality is reinforced. Suppose instead that $D_\theta > 0$: For example, more patient choice and lower access costs encourage an overall increase in demand. Then the second term in (5) is negative and the positive effect of competition on quality is weakened (or potentially overturned).

The first order condition (3) shows that if the marginal intrinsic concern with quality ($b_q - \varphi_q$) is positive and sufficiently large, the hospital could choose to produce positive quality even if the price cost margin is negative. In this case, an increase in competition which increases the effect of quality on demand ($D_{q\theta} > 0$) can reduce quality even if the marginal cost of output is constant with respect to output and quality, since then (see 4) $\pi_{q\theta} = (p - c_D)D_{q\theta} < 0$. With a negative price-cost margin, the effect of competition on quality (through the higher responsiveness of demand $D_{q\theta}$) is reversed. The hospital reduces quality to offset the increase in demand since more patients reduce profit.

Intrinsic Motivation and Altruism

The possibility that providers are altruistic or motivated has long been recognised in the health economics literature. Becoming a physician requires several years of demanding training on how to cure patients. Medical schools in most countries require graduating students to take a modernised version of the Hippocratic Oath. Although physicians may not act as "perfect" agents for the patients, they may act at least as "imperfect" ones (McGuire, 2000). Moreover, doctors may have reputational concerns and may not want to be perceived as bad doctors by the community (patients and their peers).

In the previous section we assumed that intrinsic concerns related only to the quality of care. However, if providers are concerned about the effect of quality on patients, rather than just taking pride in quality per se, they should also take account of the number of patients affected by their quality. Thus, in line with the seminal paper by Ellis and McGuire (1986), we could write the intrinsic benefit component as $\alpha B(D(q, \theta), q)$, $B_D > 0$, $B_q > 0$, where $B(D, q)$ is the benefit to patients as perceived by the provider and the parameter $\alpha \in [0,1)$ captures the altruistic concern that providers have towards patients. More generally, we could change the specification of the benefit component to allow for providers to also take pride directly in their quality by writing the benefit function as $B'(D(q, \theta), q, \alpha) = \alpha B(D(q, \theta), q) + b(q)$. This additional incentive to provide quality could be due for example to self-esteem or concerns over recognition in front of their peers and colleagues. It would be on top of the altruistic motive which is driven by patients' benefits. Note however that it is not possible to have a patient benefit function which respects patient preferences and which has the form $B(D(q, \theta), q)$, since patients demand care up to point where the benefit to the marginal patient is zero and $B_D = 0$. Hence, using this form assumes implicitly that providers do not fully take account of patient preferences (see Appendix for a formal statement).

It also seems sensible to recognise that the effort cost of producing quality will depend on the number of patients treated. Thus we can now write effort cost as $\varphi(D(q, \theta), q)$ instead of $\varphi(q)$. With these assumptions the optimality condition for quality is similar to (3) but the marginal benefit from the altruistic provider is now $\alpha B_q + \alpha B_D D_q$ and marginal effort cost is $\varphi_q + \varphi_D D_q$.

The optimal quality is now defined by

$$(1-\delta)\left[(p - C_D)D_q - C_q\right] + \alpha B_q + \alpha B_D D_q = \varphi_q + \varphi_D D_q \qquad (6)$$

and the effect of competition on quality is

$$\frac{\partial q^*}{\partial \theta} = \frac{-1}{V_{qq}}\{[(1-\delta)(p-C_D)+\alpha B_D-\varphi_D]D_{q\theta} \\ +\left[\alpha B_{DD}D_q-\left(\varphi_{DD}D_q+\varphi_{Dq}\right)-(1-\delta)\left(C_{DD}D_q+C_{Dq}\right)\right]D_\theta\} \tag{7}$$

Whether a more responsive demand implies an increase in quality (ie whether the first term in the first square bracket is positive) depends on the degree of altruism. To see this, we can re-write the optimality condition (6) as

$$(1-\delta)(p-C_D)=\frac{\varphi_q+(1-\delta)C_q-\alpha B_q}{D_q}+\varphi_D-\alpha B_D \tag{8}$$

This expression is negative for sufficiently low marginal monetary and non-monetary cost for quality and high enough altruism (α). Again, the presence of altruism may induce providers to work at a negative profit margin and therefore alter the effect of competition on quality. A higher responsiveness of demand may imply lower quality.

Altruism also alters the effect of competition on quality via the direct demand effect (second square bracket term of the numerator of (7)). For example, if the marginal benefit from treatment is decreasing ($B_{DD} < 0$) and competition implies lower demand for each provider ($D_\theta < 0$), then more competition tends to further increase quality. This arises because at lower levels of demand, the benefit from quality for the marginal patients is higher.

Competition

Intuitively a hospital faces a more competitive market if the effect of its quality on its demand increases. The previous sections used a specification with a single hospital to bring out some key determinants of the effect a policy change which made demand more responsive to quality. Now we consider a market with several firms to see how this modifies the previous results.

Strategic Interaction

We first consider how each hospital reacts to changes in the quality of rival hospitals. To focus on the strategic interactions suppose that hospital i is concerned only by its profits which are

$$\pi(q_i) = T + pD_i(q_i, q_{-i}, \theta) - C(D_i(q_i, q_{-i}, \theta), q_i) \tag{9}$$

where q_i is the quality of hospital i, and q_{-i} is (a vector of) the quality of the rival $N - 1$ hospitals, where $N \geq 2$ is the total number of hospitals in the market.[1] Hospital i takes the quality of its rivals as given and chooses its quality to satisfy[2]

$$\pi_{qi} = [p - C_D(D_i(q_i, q_{-i}, \theta), q_i)]D_{iq_i}(q_i, q_{-i}, \theta) - C_{q_i}(D_i(q_i, q_{-i}, \theta), q_i) = 0 \tag{10}$$

The dependence of the quality of hospital i on the qualities of its rivals is captured in the reaction function which solves (10)

$$q_i^R = q_i^R(q_{-i}, \theta) \tag{11}$$

Totally differentiating (10) with respect to the quality q_j of rival j we obtain

$$\frac{\partial q_i^R}{\partial q_j} = \left(-\pi_{q_i q_i}\right)^{-1}\left[\left(p - C_{D_i}\right)D_{iq_i q_j} - \left(D_{iq_i}C_{D_i D_i} + C_{D_i q_i}\right)D_{iq_j}\right] \tag{12}$$

The slope of the reaction function depends on its demand and cost functions. We assume that $D_{iq_j} < 0$ (otherwise j would not be a rival of hospital i). The reaction function is flat and qualities are independent if the demand function is linear in qualities ($D_{iq_i}q_j = 0$) and the marginal cost of treatment is constant and independent of quality ($C_{D_i D_i} = C_{D_i q_i} = 0$).

1. The following is adapted from Gravelle *et al.* (2014).
2. The Second Order condition is:

$$\pi_{q_i q_i} = \left(p - C_{D_i}\right)D_{iq_i q_i} - 2C_{D_i q_i}D_{iq_i} - C_{D_i D_i}D_{iq_i}^2 - C_{q_i q_i} < 0$$

In these circumstances provider *i* never alters quality in response to a change in a rival's quality.

The reaction function is positively sloped if the marginal cost of treatment is increasing in the number of patients treated ($C_{D_iD_i} > 0$) or increasing in quality ($C_{D_iq_i} > 0$), the price-cost margin is positive and an increase in rivals' quality increases the responsiveness of demand to provider's quality ($D_{iq_iq_j} > 0$). In this case, the hospital responds to an increase in a rival's quality by also increasing quality: their qualities are strategic complements. An increase in rival's quality reduces demand of hospital *i*, so that the marginal cost of treatment is reduced (because $C_{D_iD_i} > 0$), thereby increasing the profit margin ($p - C_{D_i}$). Moreover, it directly reduces the marginal cost of quality (because ($C_{Diq_i} > 0$)).

Conversely, the reaction function is negatively sloped if the marginal cost of treatment is decreasing ($C_{Diq_i} < 0$), the marginal cost of treatment is decreasing in quality ($C_{Diq_i} < 0$), the price-cost margin is positive and an increase in rivals' quality reduces the responsiveness of demand to provider's quality ($D_{iq_iq_j} < 0$). In this case, qualities are strategic substitutes. The results are summarised in Table 1.1.

Table 1.1 – Hospital Reaction Function (Sufficient Conditions)

	$C_{D_iD_i}$	$C_{D_iq_i}$	$D_{iq_iq_j}$
Qualities strategic independant	0	0	0
Qualities strategic complements	> 0	> 0	> 0
Quallities strategic substituers	< 0	< 0	< 0

Next consider the effect of a change in competition on the hospital's quality, holding the qualities of rivals constant. We have

$$\frac{\partial q_i^R}{\partial \theta} = \left(-\pi_{q_iq_i}\right)^{-1}\left[\left(p - C_{D_i}\right)D_{iq_i}\theta - \left(D_{iq_i}C_{D_iD_i} + C_{Diq_i}\right)D_{i\theta}\right] \qquad (13)$$

which is in line with equation (5), and has the same intuition.

To investigate the full effect of more competition we need to examine its effect on the Nash equilibrium of the market. Assuming symmetry, the Nash equilibrium is derived by solving the N reaction functions $q_i^R = q_i^R(q_{-i}, \theta)$ simultaneously to yield

$$q_i^E = q_i^E(\theta), \qquad i = 1, \ldots, N. \tag{14}$$

The properties of the reactions functions $q_i^R(q_{-i}, \theta)$ are crucial to predicting the Nash equilibrium effects of more competition. To illustrate, suppose there are two hospitals in the market. The effect on the Nash equilibrium quality of hospital 1 to an increase in competition is

$$\frac{\partial q_i^E}{\partial \theta} = \left[\frac{\partial q_i^R}{\partial \theta} + \frac{\partial q_i^R}{\partial q_j} \frac{\partial q_j^R}{\partial \theta} \right] \Delta^{-1} \tag{15}$$

where

$$\Delta = 1 - \frac{\partial q_i^R}{\partial q_j} \frac{\partial q_j^R}{\partial q_i} > 0, \tag{16}$$

and where the sign of Δ follows from the requirement that the equilibrium should be stable (Dixit, 1986).

We see from (15) that whilst it is not necessary for quality to be a strategic complement for either hospital for the pro-competitive policy to increase quality for both hospitals, in general the magnitude of the pro-competitive effect will depend on the slopes of the hospital reaction functions with respect to rival quality. With identical hospitals $\frac{\partial q_i^R}{\partial \theta} = \frac{\partial q_j^R}{\partial \theta}$,we have

$$\frac{\partial q_i^E}{\partial \theta} = \frac{\partial q_i^R}{\partial \theta} \left(1 - \frac{\partial q_i^R}{\partial q_j} \right)^{-1} \tag{17}$$

and the direct effect of policy $\partial q_i^R / \partial \theta$ is amplified by interdependencies in hospital demand functions. The amplification is increasing in the cross effect $\partial q_i^R / \partial q_j$. The key insight is that the effect of competition on quality is amplified when qualities are strategic complement and reduced when they are strategic substitutes.

Hotelling

One disadvantage of specifying the demand function of the provider as $D(q, \theta)$ is that this specification is reduced-form and no micro-foundations based on patient preferences are provided. Therefore, we have no clear guide on what we should expect in terms of competition affecting overall demand (D_θ) and its responsiveness to quality ($D_{q\theta}$). In the next two subsections we discuss two specifications of the demand functions, and emphasise the relative merits of different modelling strategies.

A popular micro-founded specification of the demand function is within a Hotelling set-up with two hospitals where the two hospitals are located at each endpoint of the line segment $S = [0,1]$. In its simplest specification, patients are uniformly located on S with a total mass of one, and each patient demands one unit of health care (eg an elective surgery) from their most preferred hospital. The utility of a patient located at $x \in S$ receiving care from hospital i is given by

$$u(x) = \begin{cases} V + \beta q_1 - tx & \text{if} \quad i = 1 \\ V + \beta q_2 - t(1 - x) & \text{if} \quad i = 2 \end{cases} \tag{18}$$

where V is gross patient surplus, q_i is the quality of hospital i, β is the marginal benefit of quality, and t is a transportation cost parameter measuring the marginal disutility travelling. Demand for provider 1 is

$$D_1 = \frac{1}{2} + \frac{\beta}{2t}(q_1 - q_2) \tag{19}$$

which can also be interpreted as a market share. The parameter t is critical in a Hotelling set up and is typically interpreted as the (inverse of the) degree of competition. Lower transportation costs imply more competition. Transportation costs do not have to be interpreted literally. Policies that facilitate patients' choice (eg comparative information on quality among providers, removing institutional barriers to choice) can also be captured by lower t.

Since total demand is assumed to be fixed, in the symmetric equilibrium q^* we have $D_t = D_\theta = 0$ and $D_{qt} = -\frac{\beta}{2t^2}$(so that $D_{q\theta} > 0$) and $\pi_{qt} = (p - C_D)D_{qt}$. Therefore more competition (lower transportation costs) implies a more responsive demand and induces an increase in quality when the price-cost margin is positive and there is no altruism.

One limitation of this specification is that total hospital demand is fixed. Although it is plausible that total demand is inelastic to quality, it is likely to be not completely inelastic. One way to have demand elastic to quality, is to augment the Hotelling model with a "monopolistic" segment. Therefore, suppose that there are two patient types —denoted with *L*(*ow*) and *H*(*igh*)—differing with respect to the gross valuation of treatment. A patient demands either one treatment from the most preferred hospital, or no treatment at all. The utility of a patient of type $s \in \{L, H\}$, who is located at x and being treated at hospital 1, located at 0, is given by

$$u^s(x) = \begin{cases} V + \beta q_1 - tx & \text{if} \quad s = H \\ v + \beta q_1 - tx & \text{if} \quad s = L \end{cases} \tag{20}$$

where $V - v > 0$ measures the difference in the gross valuation of treatment between the two types. Define λ as the proportion of high-valuation (inelastic) patients and $(1 - \lambda)$ as the proportion of low-valuation (elastic) patients. The demand function is now given by:

$$D(q_i, q_j) = \lambda\left(\frac{1}{2} + \frac{\beta(q_i - q_j)}{t}\right) + (1 - \lambda)\frac{2(v + \beta q_i)}{t} \tag{21}$$

In the symmetric equilibrium we now have $D_t = -(1 - \lambda)\frac{2(v + \beta q^*)}{t^2}$

(ie $D_\theta > 0$) and more competition increases aggregate demand. In line with the previous result we have $D_{qt} = (\lambda\beta + 2(1-\lambda))t^{-2}$ (ie $D_{q\theta} > 0$) and

$$\pi_{qt} = (p - C_D)D_{qt} - \left(C_{DD}D_q + C_{Dq}\right)D_t. \tag{22}$$

The key insight is that more competition (lower transportation costs) tends to increase demand responsiveness and therefore quality. More competition also increases demand. In turn this implies that if the marginal cost is increasing or if treatment costs are increasing in quality, then the positive effect of competition on quality is dampened.

In terms of the strategic interaction, the above specification implies $D_{q_iq_j} = 0$, which simplifies the reaction function to:

$$\frac{\partial q_i^R}{\partial q_j} = \left(\pi_{q_iq_i}\right)^{-1}\left(D_{iq_i}C_{D_iD_i} + C_{D_iq_i}\right)D_{iq_j}. \tag{23}$$

Note however, that the fact that $D_{q_iq_j} = 0$ is a result of the uniform distribution of patients on the Hotelling line. If the distribution is not assumed to be uniform, then in general we have $D_{q_iq_j} \neq 0$.

Salop

One limitation of the Hotelling approach is that does not allow consideration of the effects of more competition induced by an increase in the number of hospitals. One way to introduce a demand function which allows for *n* providers is to adopt a Salop model. The model is similar to Hotelling but assumes that n hospitals are equidistantly located on a circle with circumference equal to 1. By similar computations, and assuming a total inelastic demand, we obtain:

$$D_i\left(q_i, q_{i+1}, q_{i-1}\right) = \frac{1}{n} + \frac{\beta(q_i - q_{i+1})}{2t} + \frac{\beta(q_i - q_{i-1})}{2t} \tag{24}$$

Although there are *n* providers in the market, competition is local. Therefore, increasing the number of hospitals *n* does not change the responsiveness of demand, $D_{qn} = 0$ (and $D_{q\theta} = 0$). This is somewhat counter-intuitive since one may expect a higher number of providers to increase the responsiveness of demand.[1] Moreover, we have that a larger number of hospitals implies that the demand of each hospital is correspondingly reduced, $D_n < 0$ (and therefore $D_\theta < 0$). This is natural implication since we have assumed a fixed overall demand on the circle: one extra entrant in the market will reduce demand for the others. The overall effect on the profitability of a marginal increase in quality is given by

$$\pi_{qn} = -\left(C_{DD}D_q + C_{Dq}\right)D_n. \tag{25}$$

There is a sharp difference between the interpretation of competition in terms of lower transportation costs as opposed to competition in terms of a larger number of providers. With a total fixed demand, lower transportation costs (either in a Hotelling or a Salop model) increase the responsiveness of demand ($D_{q\theta} > 0$) but have no effect on the demand of each provider ($D_\theta = 0$). In contrast, a larger number of providers within a Salop model, has no effect on the responsiveness of demand ($D_{q\theta} = 0$) but reduces the demand of each provider ($D_\theta < 0$). In a Hotelling model with a monopolistic segment, lower transportation costs increase both the responsiveness of demand ($D_{q\theta} > 0$) and overall demand ($D_\theta > 0$).

The above analysis has examined the effect of a larger number of hospitals on quality within a Salop model with fixed total demand. In some countries and institutional settings (typically publicly-funded ones), it may seem plausible to assume that areas with larger number of providers are also characterised by a larger catchment population. This scenario can be investigated by adapting the Salop model. Instead of normalising

1. The independence between the number of hospitals and the demand responsiveness to quality is caused by the assumption of constant marginal disutility of travelling. If transportation costs are convex in distance, a higher number of hospitals (implying shorter distances between hospitals) will make demand more responsive to changes in quality provision.

the catchment population to 1 we define it as a separate variable P. The demand function is now:

$$D_i\left(q_i, q_{i+1}, q_{i-1}\right) = \frac{P}{n} + \frac{P\beta\left(q_i - q_{i+1}\right)}{2t} + \frac{P\beta\left(q_i - q_{i-1}\right)}{2t} \qquad (26)$$

Suppose further that the population is proportional to the number of hospitals, ie $P = kn$ where k is a positive parameter. Then,

$$D_i\left(q_i, q_{i+1}, q_{i-1}\right) = k + \frac{kn\beta\left(q_i - q_{i+1}\right)}{2t} + \frac{kn\left(q_i - q_{i-1}\right)}{2t} \qquad (27)$$

It is straightforward to verify that the effect of competition as proxied by a larger number of providers n has a similar effect on quality to competition as proxied by lower transportation costs. A larger number of hospitals implies a more responsive demand to quality, $D_{q\theta} > 0$, but has no effect on the demand faced by each hospital, $D_\theta = 0$.

These examples show that the effect of competition policies on quality may vary with the specification of market and with what is meant by competition.

Specialisation

The models presented so far assume that hospitals compete only on quality. Hospitals may try to relax or dampen quality competition by specialising (ie offering specialised type of treatments) and attracting particular types of patient. By specialising, providers can reduce the quality competition they face in their specialist treatment. We may think of specialisation as a longer term decision than quality investment. Decisions over quality and specialisation should then be modelled sequentially, rather than simultaneously, with the choice about specialisation taken before the choice of quality.

The Hotelling model presented on page 39 can be readily adapted to investigate hospitals' incentives to specialise following Brekke, Nuscheler and Straume (2006). Assume that the utility of a patient who is located at z and seeking treatment at provider i, located at x_i, is given by

$$U(z, x_1, q_1) = V + q_1 - t(z - x_1)^2, \tag{28}$$

$$U(z, x_2, q_2) = V + q_2 - t(x_2 - z)^2, \tag{29}$$

where V is the gross valuation of medical treatment; q_1 (q_2) is quality of provider 1 (2); t is a travelling cost parameter (inverse of competition); and x_1 (x_2) is the location of provider 1 (2) on the unit line. The distance between the two hospitals can be interpreted as their degree of specialisation. If hospitals are located close to each other, for example close to the middle of the unit line, then quality competition will be fierce. Quality competition will be relaxed if hospitals are located at the extremes of the unit line. Differently from (18), we assume that transportation costs are quadratic to guarantee the existence of equilibrium.

The patient who is indifferent between seeking treatment at hospital i and hospital j is located at $\bar{z}$ such that

$$v - t(\bar{z} - x_1)^2 + q_1 = v - t(x_2 - \bar{z})^2 + q_2, \tag{30}$$

So demand for hospital 1 is :

$$D(q_1, q_2, x_1, x_2, t) = \frac{x_1 + x_2}{2} + \frac{q_1 - q_2}{2t(x_2 - x_1)}.$$

and for hospital 2 is $1 - D$. We adopt a simplified objective function of provider 1 with zero altruism and constant marginal cost $\left(C^1 = cD(\cdot) + K(q_1)\right)$:

$$\pi_1 = (p - c)D(q_1, q_2, x_1, x_2, t) - K(q_1) \tag{31}$$

where p is the regulated price, and $K(q_1)$ if the fixed cost of providing quality. In Stage 1 providers simultaneously choose locations x_1 and x_2 and in stage 2 they choose qualities q_1 and q_2. As customary, we solve by backward induction. In stage 2, quality 1 is chosen by provider 1 such that

$$\frac{p - c}{2t(x_2 - x_1)} = K'(q_1),$$

where $\frac{\partial q_1}{\partial x_1} = \frac{p - c}{2t(x_2 - x_1)^2 K''(q_1)} > 0$. If provider 1 gets closer to provider 2, quality competition intensifies and quality increases. Similarly, define $\Delta := (x_2 - x_1)$, then $\frac{\partial q_1}{\partial \Delta} < 0$ and a higher difference in location reduces quality: the further apart the two providers are located, the lower is the scope for quality competition (this is due to the assumption of quadratic costs). If $q_1 = q_2$ the profit function reduces to:

$$\pi_1 = (p - c)\frac{x_1 + x_2}{2} - K(q_1(x_1, x_2)). \qquad (32)$$

In Stage 1 hospitals determine the optimal location. Differentiating with respect to x_1, we have:

$$\frac{\partial \pi_1}{\partial x_1} = \frac{p - c}{2} - K'(q_1(x_1, x_2))\frac{\partial q_1}{\partial x_1} = 0. \qquad (33)$$

In order to ensure equilibrium existence in the two-stage game, we make an exogenous restriction on each hospital's location choice set by assuming that $x_1 \in \left[0, \frac{1}{2} - \overline{x}\right]$ and $x_2 \in \left[\frac{1}{2} + \overline{x}, 1\right]$, where $\overline{x}$ is a (small) positive number, implying that $\Delta \in [2\overline{x}, 1]$. The first-order conditions for an interior solution in the symmetric equilibrium of the location game are given by

$$\frac{\partial \pi_1}{\partial x_1} = \frac{p - c}{2}\left(1 - \frac{K'(q)}{K''(q)}\frac{1}{t\Delta^2}\right), \qquad (34)$$

$$\frac{\partial \pi_2}{\partial x_2} = -\frac{p - c}{2}\left(1 - \frac{K'(q)}{K''(q)}\frac{1}{t\Delta^2}\right). \qquad (35)$$

The key intuition is that the marginal benefit from a higher market share from less specialisation has to be traded off with more intense (and therefore costly) quality competition. There are three possible solutions:

1) *minimal differentiation* (corner solution), where the equilibrium distance between the hospitals is given by $\Delta^* = 2\overline{x}$. This arises when the

convexity of the cost function of quality is high. In this case the marginal benefit from increasing the market share from lower specialisation is always higher than the marginal cost from increased quality competition.

2) There is *maximal differentiation* (corner solution), where the providers are located at the extremes of the unit line (implying $\Delta^* = 1$). This arises when the convexity of the cost function of quality is low. In this case the marginal benefit from more specialisation in terms of reduced quality competition is always higher than the cost from reducing the market share.

3) There is *intermediate differentiation* (interior solution) with $2\bar{x} < \Delta^* < 1$. This solution is characterised by $\partial q^* / \partial t < 0$ and $\partial \Delta^* / \partial t < 0$. More competition proxied by lower transportation costs t imply a higher quality and more product differentiation/specialisation. Lower transportation costs encourage higher quality (and more intense quality competition), which the providers try to relax by locating further apart. Similarly, $\partial \Delta^* / \partial p > 0$ and $\partial q^* / \partial p > 0$. A higher regulated price increases quality but also product differentiation/specialisation. A higher price encourages higher quality (and therefore more intense quality competition), which the providers try to relax by locating further apart.

In summary, this section shows that quality incentives could be significantly altered if hospitals can compete along other dimensions such as the degree of specialised services.

Dynamic Analysis

The analysis above assumes that quality can be varied instantly and that when varied demand quickly adjusts to the new level. Demand for health care tends to respond sluggishly to changes in quality provision. Because quality is not always easily observable and because of habits or trust in specific health care providers, patients may have sluggish beliefs about quality, which in turn will make demand adjustment sluggish. If a provider increases quality, sluggish beliefs about quality imply that it will take some time before the potential demand increase is fully realised. The implications of demand sluggishness for quality provision are analysed in a differential-game dynamic setting by Brekke *et al*. (2012) and Siciliani *et al*. (2013). Both studies make use of a Hotelling framework.

The key assumptions of the model are as follows. Define the *potential demand* of Provider 1 at time τ as

$$\widehat{D}(\tau) = \frac{1}{2} + \frac{q_1(\tau) - q_2(\tau)}{2t}, \tag{36}$$

and $D(\tau)$ as the *actual demand* of Provider 1 at time τ. The law of motion of actual demand is given by

$$\dot{D}(\tau) := \frac{dD(\tau)}{d\tau} = \gamma\left(\widehat{D}(\tau) - D(\tau)\right). \tag{37}$$

The actual demand adjusts sluggishly to quality changes. At each point in time, only a fraction $\gamma \in (0,1)$ of patients become aware of changes in relative quality offered by the providers. The lower is γ, the more sluggish is demand. The parameter γ is therefore an inverse measure of the degree of demand sluggishness n the market. Sluggish demand adjustments can be due to habitual behaviour or imperfect information about quality among consumers, implying that it takes some time before changes in provider quality are observed and acted upon in the market.

As in the general set-up we assume that providers are partially altruistic and maximise a weighted sum of consumers' utility and profits. The instantaneous objective function of Provider 1 is

$$\begin{aligned} V_1(\tau) = T + pD(\tau) - \left[cD(\tau) + \frac{\beta}{2}D^2 + \frac{\theta}{2}q_1(\tau)^2\right] \\ + \alpha\int_0^{D(\tau)} (v + q_1(\tau) - tx)\, dx, \end{aligned} \tag{38}$$

Below we will discuss two cases of special interest: (i) no altruism, ie $\alpha = 0$ (with increasing marginal cost of treatment); (ii) constant marginal cost of treatment, ie $\beta = 0$ (with positive altruism).

In this type of dynamic models with strategic interactions (known as differential games) there are two main solution concepts for the Nash equilibrium: a) *open-loop solution*, where each provider knows the initial quality (and thus potential demand) of the other provider, but not quality in the following periods; b) *closed-loop solution*, where each provider knows the quality of the other provider, not only in the initial state, but also in all of the subsequent periods. The latter is therefore dynamically time consistent (but much more complicated to solve for). Since under the closed-form solution providers are allowed to revise their investment decisions more frequently, it can be interpreted as the outcome of the more competitive environment.

We first describe the open-loop solution since this gives an insight of the off-equilibrium dynamics (which are qualitatively similar under the closed-loop solution). We then compare the quality provision under open and closed-loop solution (ie the least and most competitive environment).

The optimal open-loop solution is characterised by

$$\begin{aligned}\dot{q}_1 = {} & \frac{\alpha\gamma}{\theta}\left(\frac{1}{2} + \frac{q_1 - q_2}{2t} - D\right) \\ & -\frac{\gamma}{2t\theta}(p - c - \beta D + \alpha(v + q_1 - tD)) + (\rho + \gamma)\left(q_1 - \frac{\alpha}{\theta}D\right).\end{aligned} \tag{39}$$

together with the dynamic equation (37). Define $Q := q_1 - q_2$ as the difference in quality between the two providers. The dynamics of the equilibrium are described by

$$\dot{Q} = \frac{1}{\theta}\left[\left(\alpha(3\gamma + 2\rho) - \frac{\beta}{t}\gamma\right)\left(\frac{1}{2} - D\right) + \left(\theta(\gamma + \rho) + \frac{\alpha}{2t}\gamma\right)Q\right], \tag{40}$$

$$\dot{D} = \gamma\left(\frac{1}{2} + \frac{1}{2t}Q - D\right), \tag{41}$$

which can be represented in a phase diagram in D-Q-space.

Assume $\alpha = 0$ (Figure 1.1). Suppose we start off steady state at a level where the initial demand is low: $D(0) < D^s$. One possible interpretation is the case of a provider who at time 0 enters a previously monopolistic market. The solution is then characterised by a period of increasing demand and decreasing quality. Notice that the optimal solution for the "incumbent" is precisely the opposite and it is equivalent to the case where the demand is high ($D(0) < 1/2 \Leftrightarrow 1 - D(0) > 1/2$). For this provider, we should observe a period of decreasing demand and increasing quality. A key result is that if the marginal cost of treatment is increasing, demand and quality move in opposite directions over time on the equilibrium path to the steady state. When variable costs are strictly convex in output, $\beta > 0$, marginal profits depend on actual demand. More specifically, for a given level of quality, the instantaneous marginal profit gain of higher quality is monotonically decreasing in the actual demand facing the provider, since new consumers are increasingly costly to serve. Thus, if a provider faces actual demand $D < D^s$, the instantaneous marginal profit gain of quality investments is above the steady state level and he will therefore set quality $q > q^s$. As demand increases along the equilibrium dynamic path, the marginal profit gain of quality decreases; consequently, the provider will gradually reduce quality until the steady state level is reached.

Assume $\beta = 0$ (Figure 1.2). If the initial demand for Provider 1 is above one half $\left(D > \frac{1}{2}\right)$, then the quality difference Q is strictly positive and converges towards zero as D converges towards the steady-state level $\left(\frac{1}{2}\right)$. Intuitively, if the initial demand is above one half, the marginal benefit from quality (through the altruistic motive) is higher for Provider 1 as quality affects a larger number of consumers. Thus, for $D_0 > \frac{1}{2}$, Provider 1 has a stronger incentive than Provider 2 to provide quality in the initial period of the game, implying a positive initial quality difference: $Q(0) > 0$. However, on the equilibrium dynamic path, the quality difference is sufficiently small such that $\hat{D}(Q) < D_0$, implying that Provider 1's potential demand is lower than its actual demand. As demand for Provider 1 reduces over time, this provider's incentive to invest in quality reduces correspondingly, while the opposite is true for the rival provider. This process continues until the steady state where quality and demand differences vanish. In this scenario demand and quality move in the same direction over time.

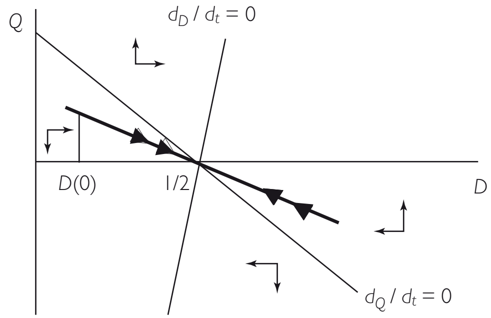

Figure 1.1 – Quality and Demand Move in the Same Direction over Time.

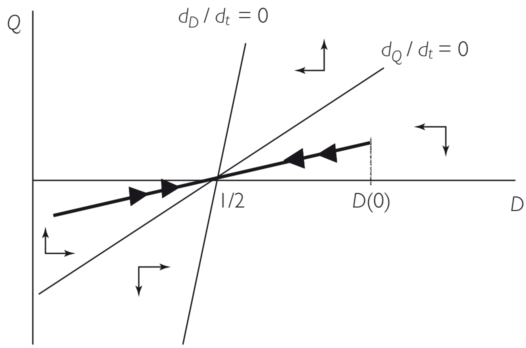

Figure 1.2 – Quality and Demand Move in Opposite Direction over Time.

In the symmetric game in the steady state under the open-loop solution we obtain

$$q^{OL} = \frac{(2(p-c)-\beta)\gamma + \alpha(\gamma(2v+t)+2t\rho)}{4\theta t(\gamma+\rho)-2\alpha\gamma} \tag{42}$$

where it can be shown that less sluggish demand (more competition) increases quality, $\partial q^{OL} / \partial\gamma < 0$.

We now move to the closed-loop solution, which is as mentioned above can be interpreted as the more competitive environment. We investigate whether quality is higher in the more "competitive" environment (as we may perhaps intuitively expect). It is useful to distinguish three special cases.

First, assume that altruism is zero and the marginal cost of treatment is constant ($\alpha = \beta = 0$). Then, quality under the two solution concepts are identical.

Second, assume that altruism is zero and the marginal cost of treatment is increasing ($\alpha = 0$; $\beta > 0$). Then quality is lower under the closed-loop solution. The reason is that quality choices are strategic complements in this case. In a dynamic game, this provides an incentive to compete less aggressively.[1]

Third, assume that altruism is positive and the marginal cost of treatment is constant ($\alpha > 0$; $\beta = 0$). Then quality is higher under the closed-loop solution. The intuition is that the presence of motivated providers affects the strategic nature of quality competition. Suppose that Provider 1 increases its quality. This reduces the number of patients of Provider 2 and therefore also reduces the marginal benefit of quality investments

1. A similar results is derived in Brekke *et al.* (2010), where demand adjust instantaneously but quality is akin to a stock $q(\tau)$ which increases over time τ only if the investment in quality $I(\tau)$ is higher than its depreciation rate: $\partial q(\tau) / \partial\tau = I(\tau) - \delta q(\tau)$. Quality provision is found to be lower in the more competitive environment, where providers are allowed to revise their quality decisions more frequently.

for altruistic reasons. Consequently, Provider 2 responds by reducing its quality. Qualities are now *strategic substitutes*. If the price is sufficiently high, this strategic substitutability makes dynamic competition tougher in the feedback closed-loop solution, where players can set their quality choices according to the evolution of demand and taking into account the strategic interaction at each instance of time. By increasing its quality today, Provider 1 can provoke a quality reduction from its competitor tomorrow (and vice versa). To summarise, since competition is more intense under the closed-loop solution and qualities are strategic substitutes (due to providers' altruism), providers' incentives to raise quality are amplified under this solution concept.

Soft Budgets

An important feature of many health care systems, is that providers, especially publicly owned hospitals, face soft budgets with funders partially covering deficits or partially confiscating profits (Kornai, 2009). This section explores the implications of soft budgets on quality competition. We provide a simplified version of Brekke, Siciliani and Straume (2015) which assumes that demand is uncertain and that patients can choose which hospital to be treated at based on quality. Surpluses occur in the low demand state, whereas deficits occur in the high demand state. This arises because providers cannot increase prices when demand is high (prices being regulated), and because hospitals cannot turn down patients who demand treatment.[1]

Within a Hotelling set up where hospitals have fixed location at the extremes of the unit line, the patient who is indifferent between the two hospitals is located at $\hat{x} = \frac{1}{2} + \frac{q_1 - q_2}{2t}$. The two hospitals face

1. Empirical papers on soft budgets in the hospital market include Duggan (2000), Shen and Eggleston (2009), and Eggleston and Shen (2011); see Eggleston (2008) for a different theory.

uncertainty about the total number of patients seeking treatment. The distribution of patients is known and given, but the density can take one of two values. In *state L*, which occurs with probability μ, demand is low with a density function equal to $f(x) = 1$ and a mass of patients in each location x normalised to one, while in *state H*, demand is high with a density function still equal to $f(x) = 1$ and a mass in each location x equal to $n > 1$ so that demand is higher in *state H*. Thus, the demands for treatment in hospital 1 is

$$d = \begin{cases} \hat{x} & \text{in State } L \\ n\hat{x} & \text{in State } H \end{cases} \tag{43}$$

The profit of Hospital i in *state j* is given by

$$\pi_i^j = pD^j - \frac{c}{2}\left(D^j\right)^2 - \frac{k}{2}q_i^2, \tag{44}$$

where p is as usual the fixed price, and c_i and k are cost parameters related to output and quality investment, respectively. Positive profits are confiscated by the regulator with a probability θ. β is the probability that a hospital running a deficit will be bailed out and can be interpreted as a measure of the degree of budget softness. The expected payoff of Hospital i is given by

$$\Pi_i = \mu(1-\theta)\pi_i^L + (1-\mu)(1-\beta)\pi_i^H, \tag{45}$$

where we assume that hospitals have a positive profit in *state L* and a negative profit in *state H* $\left(\pi_i^L > 0 \text{ and } \pi_i^H < 0\right)$. Equilibrium quality is given by

$$q^* = \frac{\mu(1-\theta)\left(p - \frac{c}{2}\right) + (1-\mu)(1-\beta)n\left(p - \frac{nc}{2}\right)}{2kt(1-\beta+\mu(\beta-\theta))}. \tag{46}$$

When making quality choices in the face of uncertainty, each hospital chooses optimally to invest in quality up to the point where the expected marginal revenue is equal to the marginal cost of quality. The marginal revenue of quality investments is the increase in demand (due to higher quality) times the profit gain of treating these extra patients. In equilibrium, this profit gain (i.e., the profit margin) is positive in *state L* and negative in *state H*, which means that *state H* contributes negatively to the expected marginal revenue of quality investments.

The effect of softer budgets on equilibrium quality is given by

$$\frac{\partial q^*}{\partial \beta} = \frac{\mu(1-\theta)(1-\mu)(n-1)((n+1)c-2p)}{4kt(1-\beta+\mu(\beta-\theta))^2} > 0. \tag{47}$$

A softer budget reduces the expected deficit in *state H*, which implies that the profit margin becomes less negative in this state. This means that the expected revenue of quality investments increases, which consequently strengthens each hospital's incentive for investing in quality.[1]

The effect of profit confiscation on quality is given by

$$\frac{\partial q^*}{\partial \theta} = \frac{\mu(1-\beta)(1-\mu)(n-1)((n+1)c-2p)}{4kt(1-\beta+\mu(\beta-\theta))^2} < 0. \tag{48}$$

A higher probability of profit confiscation reduces the profit margin in *state L* and therefore reduces the marginal revenue of quality investments, implying that the hospitals have weaker incentives for quality provision.

Increased competition (interpreted as a reduction in t) affect equilibrium quality provision in the following way:

$$\frac{\partial q^*}{\partial t} = -\frac{\mu(1-\theta)\left(p-\frac{c}{2}\right)+n(1-\mu)(1-\beta)\left(p-\frac{nc}{2}\right)}{2kt^2(1-\beta+\mu(\beta-\theta))} < 0, \tag{49}$$

1. Brekke *et al*. (2014) show that the effects of soft budgets on quality are ambiguous when providers can expend cost-containment effort (i.e., reduce the marginal cost of treatment) to increase their profit margin. The reason is that softer budgets reduce cost-containment effort, which in turn enhances the negative effect of profit confiscation on quality and counteracts the positive effect of bailouts on quality. Therefore, soft budgets can reduce quality if the effect on cost-containment effort is sufficiently pronounced.

The effect of increased competition on quality is composed of two opposite sub-effects, as represented by the two terms (with opposite signs) in the numerator of (49). A reduction in t increases demand responsiveness to quality, which stimulates quality incentives if the profit margin is positive but discourages quality incentives if the profit margin is negative. Although the profit margin is negative in equilibrium in *state H*, the expected profit margin is nevertheless positive, implying that the first term in the numerator of (49) is larger (in absolute value) than the second term. Thus, in line with the existing theoretical literature on competition between profit-maximising hospitals facing fixed prices, we find an unambiguously positive relationship between competition intensity and equilibrium quality. In summary, the presence of soft budgets does not qualitatively alter the predictions of competition on quality.

Optimal Price Regulation

The analysis so far has assumed that the price p received by the hospital for each patient treated is fixed at an exogenous level. In current payment systems this often reflects the average cost of provision. We can ask from a normative perspective what is the optimal price that would maximise welfare. We define welfare as the difference between patients benefits and costs, possibly weighted by the opportunity cost of public funds λ, i.e. $B(.) - (1 + \lambda)[C(.) + \varphi(.)]$. The optimal (first-best) quality is given by

$$\begin{aligned} &B_q(q^F) + B_D(D(q^F,\theta))D_q(q^F,\theta) \\ &= (1+\lambda)\left[C_D(D(q^F,\theta))D_q(q^F,\theta) + C_q(q^F) + \varphi(q^F)\right]. \end{aligned} \tag{50}$$

We can compare this condition with the optimality condition of the provider (3), reproduced here for reader's convenience:

$$\begin{aligned} &(1-\delta)\left[(p - C_D(D(q^*,\theta)))D_q(q^*,\theta) - C_q(q^*)\right] \\ &+ \alpha B_q(q^*) + \alpha B_D(D(q^*,\theta))D_q(q^*,\theta) = \varphi_q(q^*). \end{aligned} \tag{51}$$

The optimal price which implements first-best quality is:

$$p^f = \left[\beta_q(q^F) + B_D(D(q^F,\theta))D_q(q^F,\theta)\right]\frac{(1-\alpha)}{(1-\delta)} \\ -\frac{(\lambda+\delta)}{(1-\delta)}\left[C_D(D(q^F,\theta))D_q(q^F,\theta) - C_q(q^F)\right] - \frac{\lambda}{(1-\delta)}\varphi_q(q^F). \quad (52)$$

Qualitatively, this condition suggests that the optimal price is proportional to marginal patients' benefit. Higher altruism generally implies a lower price: since the provider is already motivated, it needs to be incentivised to a lower extent through a price mechanism. Profit constraints instead imply that providers will respond less to financial incentives and competition and therefore implies a higher price. Higher opportunity cost of public funds, which effectively implies a higher cost of quality, implies a lower price.

This section shows that if the regulator can implement first-best prices, then a policy that encourages competition has no bite. Even if hospital quality responds to competition, the regulator can always adjust the price to implement the first-best quality. Perhaps paradoxically, a regulator could respond to a policy which encourages competition by lowering the optimal price to avoid an excessively high provision of quality (ie $\partial p^F / \partial \theta < 0$). This type of reasoning also suggests that policymakers believe that current (average-cost based) prices are too low since they try to encourage increases in quality by fostering competition.

Endogenous Price

This final section provides a model of competition when providers compete on prices in additional to quality, ie prices are not fixed. The model could be applied for example to England in the period that precedes Payment by Results (introduced in 2003) where Health Authorities had to negotiate (some sort of unit) prices with different hospitals. It also captures some features of the US healthcare market; hospitals' payment for patients outside of Medicare and Medicaid (the public programmes that cover the elderly and the poor) are not subject to fixed-price rules. It also applies to those markets where patients have to pay a proportion of the price charged by hospitals. The model shows that the predictions of the effect of competition on quality are even more ambiguous when price is endogenous than when price is fixed.

To illustrate the effect of competition on quality under endogenous price, we adopt a Hotelling model with two hospitals equidistantly located on unit line equal to 1 (as (18)). This a simplified version of the model contained in Brekke, Siciliani and Straume (2010).[1] The utility of a patient located at x is $U_i = v + \beta q_i + u(Y - \gamma p_i) - tx$, where Y is gross income, γ is the proportion of the price paid by the patient and $u(.)$ is a function weakly concave in net income. Demand for hospital 1 is

$$D = \frac{1}{2} + \frac{\beta(q_1 - q_2)}{2t} - \frac{u(Y - \gamma p_2) - u(Y - \gamma p_1)}{2t}. \tag{53}$$

with $\dfrac{\partial D}{\partial q_i} = \dfrac{\beta}{2t} > 0$ and $\dfrac{\partial D}{\partial p_i} = -\dfrac{\gamma}{2t} u_y < 0$. Hospitals are profit maximisers. Hospital i's profits are $\pi_i = p_i D - C(D, q_i)$. Hospitals choose price and quality simultaneously.[2] The first-order conditions for price and quality are given by

$$\frac{\partial \pi_i}{\partial p_i} = D + [p_i - C_D(D, q_i)]\frac{\partial D}{\partial p_i} = 0, \tag{54}$$

$$\frac{\partial \pi_i}{\partial q_i} = [p_i - C_D(D, q_i)]\frac{\partial D}{\partial q_i} - C_q(D, q_i) = 0. \tag{55}$$

1. See Barros and Martinez (2012) and Gaynor and Town (2011) for reviews of the literature where prices are bargained between purchaser and provider. See also seminal paper by Spence (1975).
2. It may be more plausible to assume that price and quality are chosen sequentially, with quality being a longer-term decision than price. This does not qualitatively affect the key insight of this section, ie that the effect of competition on quality is ambigous.

In the symmetric equilibrium, the price satisfies:

$$p^* - C_D\left(\frac{1}{2}, q^*\right) = \frac{t}{2\gamma}\frac{1}{u_y\,(Y - \gamma p^*)}. \tag{56}$$

This provides the familiar monopolistic pricing rule, which suggests that the price mark up is inversely related to the degree of competition (lower transportation costs). Substituted in the optimal quality condition, under symmetry, the optimal quality satisfies:

$$\frac{\beta}{2\gamma u_y\,(Y - \gamma p^*)} = C_q\left(\frac{1}{2}, q^*\right). \tag{57}$$

A reduction in transportation costs (more competition) has the following effects:

$$\frac{\partial p^*}{\partial t} = \frac{(p^* - C_D)\,\gamma u_y C_{qq}}{\Delta t^2}, \qquad \frac{\partial q^*}{\partial t} = \frac{(p^* - C_D)\,\beta u_{yy}}{\Delta t^2 n u_y}, \tag{58}$$

where $\Delta > 0$ is a function of the model's parameters. Lower transportation costs affect equilibrium prices and quality as follows: (i) If utility is linear in income, prices fall while quality is unaffected; (ii) If utility is strictly concave in income, prices fall while quality increases. The result that more competition reduces prices is standard. The effect on quality is less obvious. Increased competition implies that demand becomes more responsive to both price and quality. This gives each hospital an incentive to reduce the price and increase quality. However, a price reduction implies a lower price-cost margin, which reduces the incentive to provide quality. Due to these two counteracting effects, the total equilibrium effect of increased competition on quality is *a priori* ambiguous. The results show that the total effect depends crucially on the marginal utility of income. If the marginal utility is constant, the two effects cancel each other out and the equilibrium quality level is independent of t, as in Ma and Burgess (1993) and Gravelle (1999). However, if utility is strictly concave, the indirect effect on quality incentives through a lower price-cost margin is reduced, implying that lower non-monetary transportation costs will increase the equilibrium supply of quality. Thus, with a decreasing marginal utility of income, consumers benefit from more competition along all dimensions as prices fall while quality increases.

Conclusions

We have investigated the effect of competition on quality under a range of assumptions which characterises the hospital sector. A key insight is that altruistic preferences, cost structure, profit constraints and other features are important in shaping the effect of competition on quality. We have also highlighted how competition can have different meaning; for example, it can be related to the number of providers or to the cost for the patient of exercising choice (eg choosing a provider that is not close from home).

The current empirical literature makes use of two main measures of market structure: the number of hospitals within a catchment area with a fixed radius or the Herfindahl index, which is given by the sum of the square of the (predicted) market shares. The first measure corresponds precisely to one of the interpretations we have given to the competition parameters. The second measure, ie the Herfindahl index, is useful when hospitals have different market shares. If market shares in a hospital catchment area are identical, the Herfindahl index is simply the inverse of the number of hospitals in the catchment area and conveys no additional information. Most of the current theoretical literature assumes symmetric markets for tractability reasons. Developing closer links between theoretical models and empirical measures of market concentration with asymmetric market shares is an interesting venue for possible future research. A third measure related to competition in the empirical literature is the extent of patients' choice policies and how these have affected hospitals' incentive to compete. Patients' choice policies can be interpreted in our theoretical model as a reduction of costs (transportation and other) from switching from one provider to another one, and are therefore closely connected to the models covered in this review.

The empirical evidence on the effect of hospital competition from the US under fixed prices is somewhat mixed. Kessler and McClellan (2000) for example find a positive effect of competition on quality in the healthcare sector (with fixed prices), Gowrinsankaran and Town (2003) find a negative effect, Shen (2003) finds mixed effects, and Shortell and Hughes (1988) and Mukamel, Zwanziger and Tomaszewski (2001) find no effect. Colla *et al*. (2018) find that competition had no effect on 30-day emergency readmission rates for Medicare hip and knee replacement patients and reduced quality for dementia patients. The recent evidence from the England generally finds support for a positive effect of competition on quality when prices are fixed (Cooper *et al*., 2011; Bloom *et al*., 2011; Gaynor *et al*., 2013). This is in contrast to some older evidence which suggests that competition reduces quality when prices are not fixed (Propper *et al*., 2004; Burgess *et al*., 2008). The empirical evidence is generally scant for other OECD and European countries. A recent exception is Berta *et al*. (2016) who find that competition had no effect on quality in Italy.

An alternative approach to investigate whether hospitals compete is by looking at hospital strategic interaction. Gravelle *et al*. (2014) employ a spatial econometrics approach to test whether hospitals have incentive to increase quality when rival hospitals increase quality. They find that in England quality responds positively to rivals' quality for seven out of sixteen indicators, and are otherwise insignificant. These methods have been previously applied in the US to test for strategic substitution in hospital prices (Mobley, 2003; see Moscone *et al*., 2014 for a review of empirical spatial methods in health economics).

The models presented in this chapter can be adapted to capture the institutional features of other countries which are likely to differ, and to derive theoretical predictions of the effect of competition on quality under a range of institutional settings. In turn, this can guide further empirical research in other OECD countries that intend to encourage competition in the hospital.

Appendix

Suppose that the benefit for a potential patient is $mq - k$ where m is morbidity and k is the cost (monetary or non-monetary) of being treated. m varies across the population with distribution function $F(m, \theta)$ and potential patients with $m \geq m^o \equiv k/q$ demand treatment, so that, normalising the total population to 1, demand is $D = 1 - F(m^o, \theta)$. Total patient benefit is

$$B^o = q\int_{m^o} m dF(m,\theta) - k[1 - F(m^o,\theta)]$$

We can write this as a function of θ and D only by using $D - 1 + F(m^o, \theta) = 0$ to solve for $m^o = g(D, \theta)$ and getting

$$\begin{aligned} B^{oo}(D,q) &= q\int_{g(D,\theta)} m dF(m,\theta) - k[1 - F(g(D,\theta),\theta)] \\ &= q\int_{d(D,\theta)} m dF(m,\theta) - kD \end{aligned}$$

We have:

$$B_q^{oo} = \int_{g(D,\theta)} m\, dF(m,\theta) > 0 \quad \text{and} \quad B_D^{oo} = -(qm^o - k) g_D f(m^o,\theta) = 0.$$

Or write $m^o = k/q = m^o(q, k)$ and totally differentiate total patient benefit with respect to q

$$\begin{aligned} \frac{dB^o}{dq} &= \frac{d}{dq}\left\{q\int_{m^o(q,k)} m dF(m,\theta) - k[1 - F(m^o(q,k),\theta)]\right\} \\ &= \int_{m^o} m dF(m,\theta) - (q\hat{m} - k) f \frac{\partial m^o}{\partial q} \\ &= \int_{m^o} m dF(m,\theta) = \frac{\partial B^o}{\partial q} \end{aligned}$$

So actual patient benefit Bo depends only on q and θ, and not on D.

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2
Ownership and Hospital Productivity

Brigitte Dormont and Carine Milcent[1]

Abstract

There is ongoing debate about the effect of ownership on hospital performance as regards efficiency and care quality. This chapter proposes an analysis of the differences in productivity and efficiency between French public and private hospitals. In France, public and private hospitals do not only differ in their objectives. They are also subject to different rules as regards investments and human resources management. In addition, they were financed according to different payment schemes until 2004: a global budget system was used for public hospitals, while private hospitals were paid on a fee-for-service basis. Since 2004, a prospective payment system (PPS) with fixed

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payment per stay in a given DRG is gradually introduced for both private and public hospitals. Payments generally differ for the same DRG, depending on whether the stay occurred in a private or public hospital. By 2018, a convergence of payments between the private and public sector should be achieved. Pursuing such a convergence comes down to suppose that there are differences in efficiency between private and public hospitals, which would be reduced by the introduction of competition between these two sectors. The purpose of this chapter is to compare the productivity of public and private hospitals in France. We try to assess the respective impacts, on productivity differences, of differences in efficiency, patient characteristics and production composition. We have chosen to estimate a production function. For that purpose, we have defined a variable measuring the volume of care services provided by each hospital, synthetizing the hospital multiproduct activity into one homogenous output. Our data comes from two administrative sources which record exhaustive information about French hospitals. Matching these two database provides us an original source of information, at the hospital-year level, about both the production composition (number of stays in each DRG), and production factors. We observe 1,604 hospitals over the period 1998-2003, of which 642 hospitals are public, 126 are private not-for-profit and 836 are private-for-profit. This database is relative to acute care and covers more than 95% of French hospitals. We use a stochastic production frontier approach combined with hospitals fixed effects. We find that the lower productivity of public hospitals is not explained by inefficiency (distance to the frontier), but oversized establishments, patient characteristics and production characteristics (small proportion of surgical stays). Once patient and production characteristics are taken into account, large and medium sized public hospitals appear to be more efficient than private hospitals. As a result, payment convergence would provide incentives for public hospitals to change the composition of their supply for care.

Introduction

The French Hospital industry is one example of a market where public, private non-profit (NP) and private-for-profit (FP) hospitals co-exist in significant proportions: in 2007, 56% of stays for acute care occured in public hospitals, 8% in private nonprofit, and 36% in for profit hospitals (Arnault *et al*., 2009). Several administrative reports have shown that in France public and private nonprofit hospitals are more costly than for profit hospitals, for a stay in a given DRG, suggesting that productivity is rather low for public and private nonprofit hospitals (Aballea *et al*., 2006; DHOS, 2009). Defenders of public and non-profit hospitals advocates that this productivity gap is not due to a lack of efficiency but related to their mandate. Indeed, these hospitals are not allowed to select patients and have to deliver care in relation to social welfare considerations, preventing any specialization in some lucrative activity.

The purpose of this chapter is to examine to which extent differences in the composition of stays and patient characteristics might explain productivity differences that are observed in France between public, private non-profit (NP) and private-for-profit (FP) hospitals. Refering to the model of yardstick competition (Shleifer,1985), Prospective Payment Systems (PPS) are based on the assumption that hospitals are identical. Any heterogeneity in cost for a stay in a given DRG is supposed to derive from moral hazard, i.e. heterogeneity in cost reduction efforts provided by hospitals' managers. Actually, there are many other sources of cost heterogeneity, such as quality of care, patient characteristics, returns to scale, and scope economies. Dealing with adverse selection due to hospital heterogeneity in designing a PPS is an important issue on the research agenda (Ellis, 1998; Keeler, 1990; Laffont and Tirole, 1993; Ma, 1994, 1998; Pope, 1990 ; Dormont and Milcent, 2005). However, most of the litterature focuses on the reimbursement of a stay in a given DRG, without paying attention to the potential influence of the composition of stays that form the whole hospital activity.

In practice, Prospective Payment Systems lead to budgets that are linear in the number of stays in each DRG. The implicit assumption underlying such a computation is that there is no scale nor scope economies. Actually, some hospitals might receive an additional annual budget for activities such as teaching, research, palliative care, geriatry, emergency care, or for having a high proportion of low-income patients. But the payment for stays in acute care is designed as if size and composition of activity had no influence on cost per stay. Is it true? Or is this approximation illegitimate?

Our purpose is to evaluate the influence of the composition of stays on hospital productivity regarding acute care. If the stay composition has an influence on hospitals' productivity, implementing a yardstick competition is likely to induce changes in the organization of the supply for hospital care. These changes might be mergers, closing[1], ownership conversions, or simply changes in the structure of stays within hospitals, like an increase in the proportion of surgical stays. On the one hand, these changes are desirable when they lead to more efficiency in care provision. On the other hand, it is not desirable that hospitals are given incentives to select patients or to discontinue the provision of care services that are important from a social welfare perspective. For the needs to be fullfilled, many governments put mandates on public hospitals that are not shared by their for profit counterparts. Should payments be adjusted for differences in the hospital production composition ? This issue is of major importance when a yardstick competition is implemented between hospitals with different mandates.

In France, public, private non-profit (NP) and private-for-profit (FP) hospitals differ not only in their objectives. They are also subject to different mandates and to different rules as regards human resources management. Since 2004, a prospective payment system with fixed payment per stay in a given DRG has been gradually introduced for all hospitals. However,

1. Numerous mergers, closing and ownership conversions have been observed in the US care system.

two payment schedules are used, one for non-profit hospitals (public and private), one for private-for-profit hospitals. Currently, payments per stay in a given DRG are on average 27% higher in the non-profit sector (public and private) than in the for profit sector (DHOS, 2009).[1]

A convergence of payments between the non-profit and for profit sectors was planned by 2018 by the previous government, but this project has been abandoned by the subsequent government. Pursuing such a convergence comes down to supposing that differences in cost per stay are due to differences in efficiency between non-profit and for profit hospitals, which would be reduced by the introduction of competition between these two sectors. Currently, there is a strong lobbying from the for profit sector in favor of an acceleration of the process towards payment convergence. Given the current gap in payments between non-profit and for profit hospitals, such a policy would generate sizeable rents for the for profit hospitals.[2] On the one hand, these rents are justified since they derive from a payment scheme which permits the revelation of the cost for an efficient activity.[3] On the other hand, they are not fully justified if the lower cost of private hospitals is partly due to the fact that their activity is free of the constraints and mandates that affect public hospitals. Our purpose is to question the relevance of the convergence objective by analysing the causes of productivity differences that are observed between hospital types before the reform implementation. More exactly, our purpose is to disentangle the impact of hospital inefficiency per se from the impacts of the stay composition and patient characteristics.

1. Actually, the level of the average payment difference depends on whether it is computed on the basis of the casemix in the private for-profit (in which case it is equal to 21%) or public/non-profit sector (27%).

2. Indeed, in this case payments would be set in between the levels observed in the for profit and non-profit sectors.

3. Otherwise, this cost level would remain a private information of the hospital's manager (Laffont and Tirole, 1993).

Focusing on productivity, we can use a quasi-exhaustive information from an administrative file recording stays for acute care. The empirical analysis is performed on a panel of 1,604 French hospitals observed over the year 1998 to 2003, of which 642 are public, 126 private nonprofit and 836 private-for-profit. For year 2003, this database represents more than 13 millions of stays, covering about 90% of total discharges for acute care.

We suppose the production function to be identical for all hospitals. Indeed, this assumption underlies the introduction of a yardstick competition between hospitals of all types. We adopt a stochastic production frontier approach combined with hospitals fixed effects in order to evaluate to what extent differences in productivity that are observed between nonprofit hospitals (public and private) and for profit hospitals can be explained by differences in patient and production characteristics. Moreover, we examine how the assessment of efficiency can be modified when we take the composition of stays into consideration. Finally, we draw conclusions on the potential impact of payment convergence between the nonprofit and for profit hospitals.

This article is organized as follows. In part one, we provide a quick overview about the literature devoted to ownership and hospital performances. In part two, we describe the French regulation of hospital care. A description of the data is provided in part three. The econometric specification and estimation strategy are explained in part four. Our results are presented in part five, with an analysis of the components of productivity differences between hospital types. Part seven concludes.

Ownership and Hospital Performances

Numerous papers try to identify the impact of ownership structures in the hospital industry. From a theoretical point of view, differences in performance should derive from the differences in objectives under different ownership structures. In short, public hospitals have little incentives to eliminate waste while nonprofit hospitals might expand the quantity and quality of services provided beyond the socially optimal level (Newhouse,1970; Lakdawalla and Philipson, 2006). For profit hospitals are likely to be the most efficient: they maximize profit and can lower noncontractible quality to maximize return (Hart *et al*., 1997). Differences in performances among ownership types are likely to be diminished if a payment system based on yardstick competition is implemented.

The empirical litterature investigates the impact of ownership on hospital performance in two ways. Some studies examine the impact of ownership on efficiency, while other studies focus on possible supply induced demand behavior and changes in care quality associated to ownership. As concerns efficiency, empirical evidence is not very conclusive. According to Sloan (2000), there is no systematic difference between for profit and nonprofit hospitals. Burgess and Wilson (1996) underline that inefficiency has several dimensions, being reflected in radial, slack or scale inefficiency. No kind of hospital ownership appears to be more efficient in every dimension. They find that hospitals of the Veteran Administration are more efficient than FP and NP hospitals in terms of radial efficiency, but are highly inefficient as concerns scale. Other empirical studies examine whether hospital ownership influences treatment costs and quality, for patients admitted for a given illness. If hospitals are paid on a fee-for-services basis, FP hospitals have an incentive to perform more numerous and intensive procedures. It is also the case under a PPS, when a more intensive treatment results in a DRG with more weight. Sloan *et al*. (2001) show that payments on behalf of Medicare patients admitted to for profit hospitals following a stroke, a hip fracture, or a congestive heart failure, were higher than those admitted to other hospitals. These findings are consistent with other results concerning hospitals of the US care system. On the other hand, Lien *et al*. (2008) do not find significant differences in treatment expenditures for stroke or heart cardiac between NP and FP hospitals in Taiwan. Turning to the impact of ownership on quality, empirical results show that FP status (or conversion to FP) is connected to a lower care quality (Picone *et al*., 2002; Lien *et al*., 2008).

In our study, we focus on productivity and technical efficiency. We do not investigate a possible increase in expenditures due to more intensive procedures for a stay in a given DRG. We consider data at the hospital level and examine productivity and technical efficiency, taking as given the observed number of stays in each DRG.

The French Regulation of Hospital Care

In France, all hospitals are financed by a unique third-party payer, the French National Health Insurance (NHI). The patient can freely choose between public, private NP or FP hospital. In practice, he is referred to the hospital by the specialist who recommanded the hospitalization. Choosing a private-for-profit hospital gives access to better confort and reduces waiting time. There is no evidence of difference in care quality between public, non profit and for profit hospitals. Choosing a private-for-profit hospital has implications on the patient's out-of-pocket expenditures: there are in general extra fees for accomodation and extra payments to the doctor and possibly the anaesthetist. These extra fees are not covered by the NHI, but may be covered by the patient's complementary health insurance[1]. However, most complementary insurance contracts do not cover overbillings (HCAAM, 2009).

In France, public, private nonprofit and for profit hospitals are subject to different rules as regards investments, human resources management and patient selection.

In the public sector the number of beds is defined by an administrative authority, and investment is controlled through financement. Doctors, nurses and other employees are civil servants, which prevents any dismissal

1. Currently, more than 90% French people are covered by a private complementary health insurance, which is provided by the employer, or subscribed on a voluntary basis. These insurances are subscribed in addition to the NHI. Complementary health insurances have covered 13.7% of total health care expenditures in 2008.

or transfer and hampers reorganizations. Owing to their mandates, public hospitals cannot select patients and are assigned to supply a comprehensive range of hospital care services. Finally, they must be open continously: access to care must be garanteed for all, twenty-four hours a day. The characteristics of large public hospitals in France are close to the characteristics of large nonprofit hospitals in the US. They account for the majority of admissions, a medical career in public hospitals is rather prestigious, all teaching hospitals are public, and large public hospitals generally provide a high quality of care. In France, small public hospitals are not necessarily rural: there are in general located in small provincial cities. Maintaining acute care activities for small public hospitals is currently under debate: it could be better for social welfare to convert them to nursing homes dedicated to rehabilitation or long term care. Actually, geography does not matter much in France, which is not a very large country and has a reliable transportation network. Each of the 22 administrative areas *(Régions)* is endowed with a large teaching hospital that supplies all kind of acute care services and performs innovative procedures. In case of need, every citizen can be rapidely admitted in such a regional center, or in another large public hospital.

Private nonprofit hospitals are not numerous. They are subject to the same constraints than public hospitals, except that their doctors, nurses, administrative staff and employees are not civil servants. This allows for more flexibility in human resources management: in addition to easier dismissals or transfers, they are not obliged to follow the remuneration scale of the public service and can offer more generous payments to doctors.

French private-for-profit hospitals have a sizeable contribution to hospital care services: about one third of discharges in acute care occurs in for profit hospitals. One observes a growing specialization towards short stays (< 24h) and surgical stays : currently half of surgical stays take place in private-for-profit hospitals. They are subject to some administrative constraints: their number of beds is defined by a planification at the regional level and investments in hightech facilities are subject to an authorization. In practice, their bargaining power is non negligible. Doctors salaried in the public sector are allowed, for a limited amount of time per week, to work in a private hospital. They are self-employed for this part of their activity. Above all, FP hospitals have no mandate specifying their supply for care: they can specialize as they want and are allowed to select their patients. Given the existence of a unique third party payer, cost-shifting is not an issue for French hospitals. Patient selection is not mainly based on patients' income and socio-economic characteristics. Richer patients might indeed have a more generous complementary insurance that permit to raise overbilling. But the bulk of the bill is paid by the NHI, irrespective of patient's income level. On the other hand, FP hospitals have interest to select patients that need intensive care, but are in a relatively good shape (not too old, with little or no secundary diagnoses), in order to maximize their revenues, together with ensuring good outcomes and a low complication rate. On the whole, private FP hospital decisions are mostly influenced by the demand function they face and by conditions prevailing on the market for health care.

In France, for profit hospital were originally owned and operated by one physician or a group of physicians. Now this physician generation is coming to retirement age and in the process of selling these establishments to investor-owned companies seeking corporate profits. Large chains of hospitals are set up, such as Générale de Santé and Vitalia (partly owned by the investment bank Blackstone). There is no doubt that substantial financial returns are expected from such investments.

Why would public and NP hospitals be less efficient than FP hospitals? As stated above, these hospitals have different objectives and mandates and are subject to different rules relative to human resources management and patient selection. Moreover, they were financed according to different payment schemes until 2003: a global budget system was used for nonprofit hospitals (public and private), while private-for-profit hospitals were paid a mix of fee-for-service and payments per day covering accomodation.

It is not obvious that these payment schemes should entail a higher efficiency for private FP hospitals. Indeed, their payment was equivalent to a retrospective payment per stay, which does not provide incentives for efficiency. As concerns public and private nonprofit hospitals, the global budget system has been implemented with a soft budget constraint, which makes the global budget ressemble to a retrospective payment. In other words, payments implemented before 2004 did not give hospitals of any type much incentive for efficiency.

Since 2004, a Prospective Payment System (PPS) with fixed payment per stay in a given DRG is gradually introduced for both private and public hospitals. In addition to prospective payments per stay, hospitals can receive lump-sum payments to compensate for activities such as teaching, research, emergency care, preventive care, etc. (Or, 2009). Almost all of these lump-sum payments are granted to public hospitals. As stated above, two different payment schedules are currently used for the prospective payment per stay, one for private-for-profit hospitals, another one for nonprofit hospitals (public or private). This payment scheme introduces two separate arenas of yardstick competition: between for profit hospitals on the one hand, and between nonprofit hospitals, on the other hand. Thus, it provides incentives for efficiency for both hospital types. Nevertheless, owing to the lump-sum payments received by public hospitals, and to the difference in payment schedules used for the PPS, the power of incentives is probably not the same, depending on the hospital type.

In this paper, we compare the productivity and efficiency of French public, private nonprofit and for profit hospitals during period 1998-2003, i.e. before the reform that has introduced a PPS. Hence, it will be possible for us to interpret differences in performances over this period as deriving mainly from differences in mandates and objectives linked to ownership.

The Data

A vast majority of papers devoted to hospital efficiency focuses on the estimation of a cost function (see, for instance, Wagstaff, 1989; Linna, 1998; Rosko, 2001; Zuckerman *et al*., 1994; Farsi *et al*., 2005). Costs functions allow to deal with the multiproduct activity of hospitals and to check for ray[1] economies of scale, product-specific economies of scale, and economies of scope. Despite these advantages, we decided to focus on productivity and to consider a production function. Our motivation is that we aim at performing a relevant comparison of performances between hospital types. As a matter of fact, costs are generally difficult to observe in the for profit sector. For competitive reasons, information about cost is a rather sensitive information. Moreover, doctors might be part owners of for profit hospitals, which add difficulties to measure real costs and profitability. In addition, in France the cost measure is not comparable between public and private hospitals: it does not encompass the doctors' payments, nor overbilling in private nonprofit and for profit hospitals, while in public hospitals doctors are salaried and their wages included in the cost.

Taking advantage of the duality theory, we know that differences in costs between hospital ownership can result from differences in technical efficiency (distance to the frontier defined by the production function), differences in input prices (payments to care providers and wages differ in the private and public sectors), and in input allocation. Estimating a production function enables us to evaluate differences in technical efficiency, and to identify the sources of productivity differences. However, we will not be able to examine the impact on costs of differences in input prices, and to check for possible allocative inefficiency.

1. A definition of ray economies of scale can be found in Tirivayi *et al*., (2009): It refers to the reduction in average costs relative to marginal costs when a composition of output is assumed to remain fixed while its size is allowed to vary. Hence, ray economies of scale are overall economies of scale over an output set.

Definition of Production

The French classification system was inspired by the classification used in USA by the Health Care Financing Administration. In France, a complete information system that classifies inpatient stays by DRG has been set up since 1994 for non profit hospitals (public and private) and 1997 for private-for-profit hospitals. Denote N_{jht} the number of stays in hospital h in year t that have been classified in DRG j. The French administrative authority estimates the average cost per stay in a given DRG from a sample of hospitals which participate in the cost database program on a voluntary basis. These average costs are used to build the *Échelle Nationale des Coûts*, a costweight scale which is updated every year. This scale is based on relative costs and gives, for each stay in a given DRG j, the corresponding number of production units, called *ISA* points.[1]

Denote p_{jt} the number of *ISA* points attributed in year t for a stay in DRG j. It provides a measure of the volume of corresponding care services. Hence, we define the production of hospital j in year t by:

$$Q_{ht} = \sum_{j=1}^{J} p_{jt} N_{jht} \tag{1}$$

This definition synthetizes the multiproduct hospital activity by one homogenous product, measured in *ISA* points. To ensure the relevance of our comparison, we use the same "price" scale p_{jt}, $j = 1,\dots, J$; $t = 1,\dots,T$, for hospitals of any type of ownership. For the period covered by our data (1998-2003), only the cost database relative to public and NP hospitals is available.[2] Notice that we focus on the activity relative to acute-care only. As stated above, the PPS concerns the payment of acute-care stays, and does not influence directly the financing of other activities such as teaching

1. ISA stands for *Indice Synthétique d'Activité* [Synthetic index of activity].

2. A *Échelle Nationale des Coûts* for the private sector has been set up only from year 2004 on.

or research. Our purpose is to examine whether productivity relative to acute-care is influenced by the stays composition, patient structure and teaching activity.

Two Administrative Databasis

Our data stem from two administrative sources: the *PMSI* and SAE databasis. PMSI stands for *Programme de Médicalisation des Systèmes d'Informations*, which collects information about hospital activity regarding stays for acute care in all French hospitals. The information is almost exhaustive: participation to PMSI is mandatory, except for very small public hospitals with a specific status *(hôpitaux locaux)*. In PMSI database, information is recorded at the stay level about DRG, secondary diagnoses, procedures implemented, severity, mode of entry into the hospital (coming from home or transferred from another hospital), mode of discharge (return home, transfer or death), length of stay, age, and gender of the inpatient.

The SAE[1] database provides information at the hospital-year level about production factors, i.e. number of acute-care hospital beds, facilities, number of doctors, nurses, nursing auxiliairy staff, administrative staff and support staff (all are measured in full-time equivalents).

Matching these two database provides information at the hospital-year level, about the composition of hospital activity and its production factors. We eliminated hospitals for which the identification code was not recorded, preventing any match with the SAE database. We also eliminated hospitals with no bed or no employees: these are small establishments devoted exclusively to chemotherapy, radiotherapy or dialysis sessions.

Our final database contains 1,604 hospitals over the period 1998-2003, that is 7,731 observations at the hospital-stay level. This panel is unbalanced: not all hospitals are observed from year 1998 to year 2003. For year 2003, this database represents about 90% of total discharges for acute-care.

1. SAE stands for *Statistique annuelle des établissements*.

We consider six production factors: the number of acute-care beds, denoted *bed*, the number of physicians, denoted *phys*, the number of nurses, *nurs*, auxiliary nursing staff, *nurs_aux*, administrative staff, *adm*, and support staff, *supp*.

The number of physicians is not consistently measured across hospital types: it is well recorded for public hospitals, where doctors are salaried, but measured with errors for nearly all for profit and private nonprofit hospitals. Indeed, when self-employed physicians associated with private hospitals are recorded in the SAE database, there is no information about their work time, so we cannot calculate full-time equivalents. Moreover, the number of physicians is not recorded at all for 435 FP or NP hospitals. In order to treat equally hospitals of all types, we decided to specify the number of physicians as an omitted variable.[1] As a result, the number of physicians is a component of the hospital specific unobserved heterogeneity in our econometric specification. This component being likely to be correlated with other regressors, we have considered a model with hospital fixed effects to avoid possible bias.

Characteristics of Public, Private Non-profit and for Profit Hospitals

Figure 2.1 to 2.3 and Table 2.1 display the main features of the data. 1,604 hospitals are observed, of which 642 hospitals are public, 126 are private nonprofit (NP) and 836 are private-for-profit (FP). For the purpose of the analysis, we have considered three size groups: small hospitals, with less than 5,000 discharges per year, large hospitals with more than 10,000 discharges per year, and medium hospitals in between.

1. Indeed, our purpose is to compare productivity and efficiency between hospital types. In this case it is relevant to specify the number of physicians as an omitted variable. This doesn't allow for an estimation of physician productivity, but enables us to implement a relevant comparison. For hospitals of the USA, the same empirical strategy has been followed by Burgess and Wilson (1996).

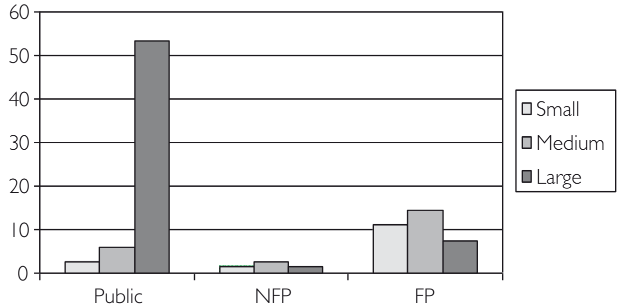

Figure 2.1. – Contribution to Hospital Care Services.

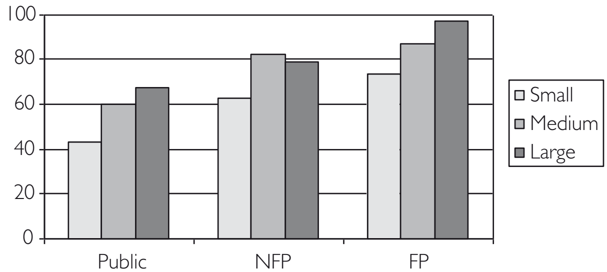

Figure 2.2. – Productivity: Annual Number of ISA Points (thousand) per Bed.

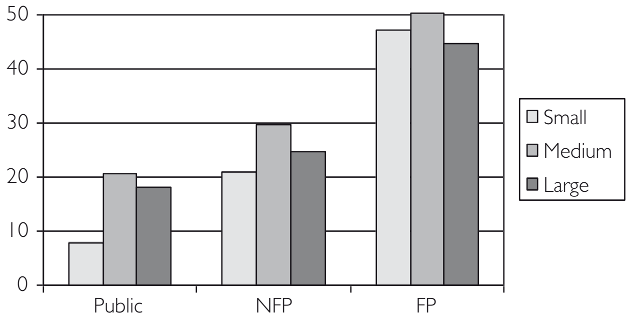

Figure 2.3. – Proportion of Surgical Stays.

On the whole, 62.9% of discharges occurred in public hospitals, 4.6% in private nonprofit hospitals, and 32.5% in for profit hospitals. Figure 2.1 shows that the bulk of hospital care services, measured by production indicator (1) comes from large public hospitals, while for profit hospitals of any size have a smaller contribution to care services. Measuring productivity by the annual number of ISA points per bed, we find that public hospitals of any size are less productive than private nonprofit and for profit hospitals (Table 2.1 and Figure 2.2). One observes also an amazing proportion of surgical stays, close to 50% in for profit hospitals of any size (Figure 2.3). Table 2.1 displays more detailed information about hospital characteristics. Small for profit hospitals appear to be quite numerous with an average number of beds slightly higher than in small public hospitals (58 *versus* 45). For profit medium sized hospitals are also twice more numerous (234 establishments) than their public counterparts (117 establishments), but with less beds on average (118 *versus* 151). Large hospitals are mainly public: there are 243 large public hospitals, for only 14 large nonprofit and 61 large for profit hospitals. Large public hospitals ensure 53.4% of hospital care services. They are enormous, with 566 beds on average, to compare with the 201 beds of their for profit counterparts. In addition to a relatively low proportion of surgical stays, public hospital activity is characterized by longer stays. This is particularly striking for small public hospitals, with an average length of stay (LOS) equal to 9.3 days (3.8 days in small for profit hospitals). This difference is still observable as concerns medium-sized and large hospitals: LOS are on average 1.5 to 2 days longer in public hospitals than in private-for-profit hospitals, nonprofit hospitals staying in between (about one day longer than in for profit hospitals).

Table 2.2 displays information about the level of inputs and the organization of hospital staff. On average, there are about 3 employees per bed, with large differences depending on hospital size and ownership. Public hospitals employ more persons per bed than for profit

Table 2.1 – Basic Feature of the Data

Size	Ownership	Number of Hospitals	Number of beds per hospital	Anual number of stays per hospital	Share % in total production* [in total stays]	Average LOS* [average median LOS]	Number of stays per bed	Proportion of surgical stays %	Annual production** per bed
Small	**Public**	282	45	1,794	2.7 [3.0]	9.3 [7.1]	33	7.9	43,225
	NP	72	64	2,499	1.3 [1.1]	6.9 [4.6]	37	20.9	62,405
	FP	541	58	2,986	11.1 [11.7]	3.9 [2.3]	54	47.2	73,785
Medium	**Public**	117	151	7,129	6.0 [6.9]	5.4 [3.5]	48	20.5	60,222
	NP	40	153	6,811	2.5 [2.0]	4.5 [2.5]	45	29.8	81,914
	FP	234	118	6,823	14.3 [14.1]	3.5 [1.8]	60	50.4	87,201
Large	**Public**	243	566	26,865	53.4 [53.0]	5.3 [2.7]	49	18.0	67,390
	NP	14	339	15,303	1.6 [1.4]	4.7 [2.4]	47	24.8	78,604
	FP	61	201	12,381	7.3 [6.7]	3.8 [2.1]	63	44.6	97,242
Total		1,604 (7,731 obs)	169	8,334	100.0 [100.0]	5.1 [3.1]	50	33.5	70,517

1,604 hospitals 1998-2003, 7,731 observations in the hospital-year dimension

Small hospitals: less than 5,000 discharges per year; Large hospitals: more than 10,000 discharges per year.

* LOS is measured in days: we provide the mean of the LOS averaged at the hospital level, and the mean of the LOS median, computed at the hospital level.

** The production is measured by the number of ISA points (in thousand) hospitals: 7.6 for small public hospitals and 3.7 for medium and large public hospitals, while for profit hospitals of any size employ only 1.7 to 1.9 persons per bed. This result holds for each component of hospital staff: public hospitals have more nurses, more nursing auxiliaries, more administrative staff and more support staff per bed, than private-for-profit hospitals. The contrast is particularly pronounced as concerns the number of nursing auxiliaries per bed, which is more than six times higher in small public hospitals than in small for profit hospitals. The number of support staff per bed is also very high in public hospitals of any size.[1] As for LOS, the characteristics of private nonprofit hospitals as regards the number of employees per bed stay in between characteristics of public and for profit hospitals.

To sum up, public and nonprofit hospitals employ more persons per bed and have longer stays than for profit hospitals, suggesting a less efficient use of inputs. It might also derive from characteristics of their activity, such as the fact that they ensure a high proportion of medical stays.

1. Table 2.2 displays also statistics on doctors per bed, computed on a sub-sample of 1,169 hospitals for which the number of doctors is recorded. For private hospitals, we have no information on the work duration of part-time physicians. We considered three alternative assumptions to build a full-time equivalent measure of the number of doctors: half-time, 10% or 80% time. We obtain average numbers of doctors per bed that do not appear to be different between hospital ownership. However, it is difficult to draw any conclusion from this result, given the uncertainty about the relevance of our hypotheses. In addition, many self-employed doctors are likely to be not recorded. As stated above, the number of doctors will be treated as an omitted variable in our econometric estimations

Table 2.2 – Organization of Hospital Staff

Size	Owner-ship	Number of beds	Total persons /bed	Doctors[#] / bed	Nurses/ bed	Nursing auxili-airy staff/bed	Adm. staff/bed	Support staff/bed
Small	Public	45***	7.62***	0.24***	1.63***	3.84***	0.68***	1.23***
	NP	64***	3.56	0.20*** *[0.15 ;0.24]*	1.10	1.12	0.53***	0.62
	FP	58***	1.76***	0.26*** *[0.13 ;0.36]*	0.51***	0.59***	0.25***	0.14***
Medium	Public	151***	3.66	0.29**	1.08**	1.33***	0.38	0.57***
	NP	153***	2.62***	0.17*** *[0.15 ;0.19]*	0.83***	0.71***	0.44**	0.47***
	FP	118***	1.67***	0.22*** *[0.13 ;0.29]*	0.54***	0.58***	0.21***	0.12***
Large	Public	566$^{(ref)}$	3.65$^{(ref)}$	0.32$^{(ref)}$	1.16$^{(ref)}$	1.15$^{(ref)}$	0.39 $^{(ref)}$	0.63 $^{(ref)}$
	NP	339***	2.86**	0.13*** *[0.11 ; 0.14]*	0.95**	0.77*	0.47**	0.55
	FP	201***	1.91***	0.27*** *[0.17 ;0.35]*	0.63***	0.65***	0.21***	0.14***
Total		169	3.14	0.26	0.87	1.23	0.35	0.44

1,604 hospitals 1998-2003, 7,731 observations in the hospital-year dimension

The difference with the average level in large public hospitals is significant 1% (***), 5% (**), 10% (*)

[#] Doctors are observed on a sub sample of 1,169 hospitals only (5,798 observations on 1998-2003). For private hospitals (for profit and non profit) part-time doctors are supposed to work half time (coefficient 0.5). Between brackets is given the range obtained with two other hypotheses: coefficients 0.1 and 0.8.

Econometric Specification and Estimation

We consider a Cobb-Douglas production function with 6 production factors : *bed*, *phys*, *nurs*, *nurs_aux*, *adm* and *supp*. One has :

$$\begin{aligned} Q_{ht} = {} & A(phys_{ht})^{\alpha_1}(nurs_{ht})^{\alpha_2}(nurs\_aux_{ht})^{\alpha_3} \\ & (adm_{ht})^{\alpha_4}(supp_{ht})^{\alpha_5}(bed_{ht})^{\beta} \end{aligned} \tag{2}$$

Taking the logarithms, one obtains the linear expression:

$$\begin{aligned} q_{ht} - b_{ht} = {} & (\mu - 1)b_{ht} + \alpha_1[log(phys)_{ht} - b_{ht}] + \alpha_2[log(nurs)_{ht} - b_{ht}] \\ & + \alpha_3[log(nurs\_aux)_{ht} - b_{ht}] + \alpha_4[log(adm)_{ht} - b_{ht}] \\ & + \alpha_5[log(supp)_{ht} - b_{ht}] + a \end{aligned} \tag{3}$$

with $b_{ht} = Log(bed_{ht})$ and $q_{ht} = Log(Q_{ht})$. a is a constant term and μ is the return to scale parameter. As stated above, we prefer to treat the number of doctors as an omitted variable: it is often not recorded and, when recorded, likely to be measured with errors.

In the econometric specification we formalize hospital unobserved heterogeneity and inefficiency as follows:

$$\begin{aligned} q_{ht} - b_{ht} = & (\mu - 1) b_{ht} + \alpha_2 [log(nurs)_{ht} - b_{ht}] \\ & + \alpha_3 [log(nurs\_aux)_{ht} - b_{ht}] \\ & + \alpha_4 [log(adm)_{ht} - b_{ht}] + \alpha_5 [log(supp)_{ht} - b_{ht}] \\ & + c_t + \gamma + \delta.teach_h + v_h - u_h + \xi_{ht}. \end{aligned} \tag{4}$$

γ is an intercept, c_t is a year fixed effect, $teach_h$ is a dummy variable indicating whether h is a teaching hospital. v_h is a random variable measuring unobserved heterogeneity at hospital level and $u_h \geq 0$ is a non-negative random variable measuring hospital inefficiency. ξ_{ht} is a statitical noise supposed to be i.i.d. $(0, \alpha_\xi^2)$ and uncorrelated with the explanatory variables.

We use a two-stage approach: we first apply the OLS to estimate the following specification:

$$\begin{aligned} q_{ht} - b_{ht} = & (\mu - 1) b_{ht} + \alpha_2 [log(nurs)_{ht} - b_{ht}] \\ & + \alpha_3 [log(nurs\_aux)_{ht} - b_{ht}] + \alpha_4 [log(adm)_{ht} - b_{ht}] \\ & + \alpha_5 [log(supp)_{ht} - b_{ht}] + c_t + \eta_h + \xi_{ht}, \end{aligned} \tag{5}$$

where η_h is a hospital fixed effect.

In the second step, we use a stochastic production frontier approach (Aigner *et al.*, 1977; Jondrow *et al.*, 1982) to decompose the estimated hospital fixed effects into separate estimates of hospital specific unobserved heterogeneity v_h, and hospital inefficiency u_h. More exactly one has, from[1] (4):

$$\hat{\eta}_h = \gamma + \delta.teach_h + v_h - u_h \tag{6}$$

1. Here we do not add dummies relative to ownership on purpose, in order to examine in the following how efficiency rate distributions might vary accross hosiptal sizes and ownerships.

We assume that u_h has a strictly non-negative distribution and that v_h has a symetric distribution and apply the maximum likelihood estimator to (6). If one assumes that $v_h \sim N(0,\sigma_v^2)$ and $u_h \sim N^+(0,\sigma_u^2)$, the model is normal-half normal. Another possibility is to assume that u_h follows the exponential distribution, in which case the model is normal-exponential. The difference between the log of output q_h and its maximal value q_h^{max} given by the frontier is measured by $-u_h$. The estimation makes it possible to compute the asymmetry parameter $\lambda = \frac{\sigma_u}{\sigma_v}$, which gives an evaluation of the magnitude of the inefficiency component. In addition, we can compute an efficiency rate at the hospital level:

$$effi_h = exp\{-u_h\} = \frac{Q_h}{Q_h^{max}} \tag{7}$$

Our empirical strategy consists in considering three specifications. Our first specification is defined in (5). It is a classical production function connecting inputs and output:

$$q_{ht} - b_{ht} = x'_{ht}\alpha + c_t + \eta_h + \xi_{ht}, \qquad \text{Model 1}$$

where x'_{ht} is a [1,5] vector describing production factors, i.e. the inputs.

We also consider two other specifications:

$$q_{ht} - b_{ht} = x'_{ht}\alpha + z'_{ht}\beta + c'_t + \eta'_h + \xi'_{ht} \qquad \text{Model 2}$$

$$q_{ht} - b_{ht} = x'_{ht}\alpha + z'_{ht}\beta + \pi'_{ht}\theta + c''_t + \eta''_h + \xi''_{ht} \qquad \text{Model 3}$$

In Model 2 we add a [1,19] vector z'_{ht} describing patient characteristics: proportion of patients of given age and gender, severity, entry and discharge mode. In Model 3 we add a [1,13] π'_{ht} describing production characteristics: proportion of stays in 10 important MDC (Major Diagnostic Categories: neurology (MDC1), ophtalmology (MDC2), otorhinolaryngology (MDC3), pneumology (MDC4), cardiology (MDC5), gastroenterology (MDC6), orthopaedics (MDC8), deliveries (MDC14), short stays (shorter than

24 hours and coded[1] MDC24), degree of specialization, proportion of surgical stays. These specifications are rather "eclectic" (Vita, 1990) since variables describing heterogeneity in the output appear at the right hand side of the production function. We believe it is relevant: the variability of the added regressors is mainly composed of between hospital variability and we specify a fixed hospital effect for each equation.

Our two-step estimation is rather particular. Most papers devoted to stochastic frontier analysis use a one-step maximum likelihood estimator. For that purpose, it is assumed that hospital specific heterogeneity v_h and hospital inefficiency u_h are both uncorrelated with regressors. This assumption seems to us quite untenable: v_h is linked to omitted variables such as care quality, or the number of physicians, which are likely to be correlated with the level of inputs. Estimating a fixed effect model allows us to obtain consistent estimations of the production function parameters. Moreover, we assume that the first step estimates of η_h are consistent. This is not obvious, but makes it possible to avoid assuming an independency between regressors and random variables v_h and u_h.

Another important issue is whether hospital specific heterogeneity should affect the production function or the inefficiency component. Greene (2004) shows that within a fixed effect approach, there is no satisfactory specification: either the fixed effect is entirely absorbed in the inefficiency component, or it affects the production function only. Inefficiency is either overestimated or underestimated. Many papers suppose that the inefficiency term u_h is random and uncorrelated with the regressors of the production function, but formalize the idea that it is correlated to time and some covariates (Battese and Coelli, 1992, 1995; Rosko, 2001; Herr *et al.*, 2010). But why are these covariates excluded from the production function regressors? There is no clear-cut discussion on whether they might explain production or inefficiency.

1. Coding short stays as MDC24 is specific to France.

Consider variables z'_{ht}: in Model 2 they are added to regressors x'_{ht} to explain hospital productivity $q_{ht} - b_{ht}$. Another specification could be adopted, which consists in supposing that variables z'_{ht} explain hospital inefficiency (Battese and Coelli, 1995). In the first case these variables influence the frontier, in the second case they affect the distance to the frontier.

Our purpose is to take public hospital mandates into account in the production function specification. For instance, the fact that they are not allowed to select patients entails specific values of z'_{ht}, which reflect patient composition as regards age, gender and severity. We want to evaluate to which extent the assessment of hospital efficiency is influenced by the frontier specification. Model 1 is a classical production function. In Model 2 we add patient characteristics to the frontier specification. In Model 3 we add production composition. If Model 2 is the right specification, then Model 1 is not consistently estimated if one supposes random effects u_h and v_h and if variables z'_{ht}, which are omitted in Model 1 are correlated with regressors x'_{ht}. Estimating a fixed effect model allows us to avoid these omitted variable bias.

The production function is supposed to be identical for all hospitals. Indeed, this assumption underlies the introduction of a yardstick competition between hospitals of all types. The robustness of the results with respect to the treatment of doctors as an omitted variable has been checked by carrying the estimations on a restricted sample where physicians are observed. Our conclusions are also not changed when we consider a translog production function.

Results

The estimations of Model 1 and Model 3 are displayed in Table 2.3.[1]

All models give similar results as concerns the influence of production factors on hospital productivity (Table 2.3). Every component of hospital staff has a positive marginal productivity, except support staff, whose coefficient is negative. The positive impact of nursing auxiliaries is weakly significant, and in Model 3 only.

The negative coefficients obtained for the number of beds suggest that the returns to scale are decreasing (see expression [3]). However, such a conclusion is not relevant. Indeed, the specification includes a constant specific to each hospital, which is likely to be connected to its size. This result only means that locally, around the level corresponding to its specific constant, a decrease in the number of beds induces an increase in hospital productivity. This result does not tell anything about the optimal size of establishments, that is, about the productivity levels of hospitals of different sizes.[2]

1. We do not publish the results for Model 2, which are available on request. Indeed, this model gives estimated coefficients for patient characteristics which are quite similar to those obtained with Model 3.

2. The issue of optimal size is out of the scope of this study. However, we have estimated a production function without hospital fixed effects, including a polynomial function of the number of beds in order to examine the relation between size (measured by the bed number) and productivity. With a polynom of degree 3, we have obtained a local minimum of productivity for a size equal to 8 beds, and a maximum for a size equal to 253 beds.

Table 2.3 – Estimation Results, First Step, Dependent Variable : *Log* (*Production per Bed*)

	Model 1	Model 3
Log (*bed*)	−0,3318***	−0,4863***
Log (*nurs/ bed*)	0,2780***	0,1969***
Log (*nurs_aux/bed*)	0,0437	0,1060*
Log (*adm staff/bed*)	0,4562***	0,4092***
Log (*support staff/bed*)	−0,2973***	−0,2562***
% women 19-40		0,2445
% men 19-40		0,9419**
% women 41-50		0,0339
% men 41-50 = ref.		–
% women 51-60		−0,1185
% men 51-60		0,3850
% women 61-70		0,7537**
% men 61-70		0,3720
% women 71-80		0,4213
% men 71-80		−0,0914
% women 81-90		−0,6642**
% men 81-90		−0,2187
% women 91 +		−0,0420
% men 91 +		−0,7965
% admissions severity 1= ref.		–
% admissions severity 2		0,8239***
% admissions severity 3		1,6051***
Admission		
another hospital or care *unit= ref.*		–
home		−0,1240**
Discharge		
another hospital or care *unit= ref.*		–
home		−0,0604
other hospital		−0,0667
death		−1,0268***
% stays in CMD 1		−0,1443
% stays in CMD 2		−0,1497
% stays in CMD 3		−0,5791**
% stays in CMD 4		0,7489***
% stays in CMD 5		0,8068***
% stays in CMD 6		1,6901***
% stays in CMD 8		0,4857***

	Model 1	Model 3
% stays in CMD 14		2,0726***
% stays in CMD 23		0,3671**
% stays shorter than 24h)		0,7965***
% stays with surgery		0,9670***
Specialisation Index		0,1909***
Specialisation Intensity		−0,6586***
R^2	0,99	0,99

1,604 hospitals 1998-2003, 7,731 observations. Specifications include year dummies and hospital fixed effects.
*: significant (10%), **: significant (5%), ***: significant (1%).
MDC 1: nervous system, MDC 2: eye, MDC 3: ear, nose, mouth and throat, MDC 4: respiratory system, MDC 5: circulatory system, MDC 6: digestive system, MDC 8: musculoskeletal system and connective tissue, MDC 14: pregnancy, childbirth and puerperium, MDC 23: factors influencing health status. Specialization index = 1 if the highest proportion of stays in a given MDC is greater than 33%, intensity is equal to the value of the highest proportion of stays in a given MDC, if specialization index = 1 (otherwise it is equal to 0).

Productivity Relies on Uncomplicated Stays with Intensive Procedures

The estimation of Model 3 makes it possible to examine the impact of patient characteristics on hospital productivity, as well as the impact of production composition. The proportion of patients aged more than 80 has a negative influence on productivity, which is significant for women aged 81-90. Conversely, the proportion of women aged 61-70 has a positive impact, as well as the proportion of young men (aged 19-40). The proportion of patients of severity 2 or 3 has a positive impact on productivity. It is important to avoid any misinterpretation of the meaning of this variable: compared to the reference (severity degree equal to 1), severity degrees 2 or 3 do not indicate the presence of comorbidities with complication risks. They only indicate that an intensive, or very intensive, surgical procedure was performed. Finally, the estimations show that the proportion of patients who died during their stay has a strong negative influence on hospital productivity.

These results show how the measure of hospital production works. As stated above, it is based on a valuation of stays in different DRGs on the basis of the costweight scale (see [1], p. 81). A stay contributes to an improvement in productivity if (i) it is associated to the performance of a rather invasive procedure; (ii) it is "simple", i.e. it corresponds to a single pathology in the DRG classification. Indeed, intensive procedures are well paid in terms of *ISA* points, and a simple stay is shorter and uses less resources (for the same return in *ISA* points) than a complicated stay with comorbidities. This is why stays of very old people are unfavorable to productivity: old patients are generally affected by several illnesses or complication factors, and their frailty impedes the use of invasive procedures. For the same reason, stays with severity degrees equal to 2 or 3 greatly improve productivity, since they are associated to the performance of intensive procedures. Finally, a patient who dies in hospital is the worst case: it is generally a very old person, with many comorbidities and high complication risks. In this case, a large amount of resources is spent for a classification in a single DRG.

Estimations displayed in the lower part of Table 2.3 show the influence of the composition of hospital activity on productivity. The proportion of surgical stays has a large positive impact on productivity (a 0.1 increase in this proportion increases productivity by 9.7%). The proportion of short stays (less than 24H) also has a large positive impact: a 0.1 increase in the proportion of short stays raises productivity by 7.9%. The same mechanisms are at work: surgical stays are well paid in *ISA* points and short stays use less resources. We also find that some types of activity have a positive impact on productivity: this is the case for stays in the MDC14 (deliveries), MDC5 (circulatory system), MDC6 (digestive system), MDC4 (respiratory system) and MDC8 (orthopaedics).

The Diagnosis of Efficiency is Contingent upon Taking into Account Patient and Production Characteristics

The results of the second step of the estimation are summarized in Tables 2.4a and 2.4b. The asymmetry parameter is reduced when we introduce patient characteristics in the definition of the frontier (Model 2), and reduced further when production characteristics are added to the specification (Model 3). This shows that the estimate of the inefficiency term partly captures the influence of variables that are omitted in Model 1

The estimation makes it possible to assess the difference u_h between actual productivity and the maximal level of productivity in case of full efficiency. Hence, we can compute efficiency rates defined by (7): $effi_h = exp\{-u_h\}$. This term is interpreted as follows: $effi_h = 82.4$, for instance, means that the hospital has delivered a value of care services equal to only 82.4% of the amount it could have provided if it were fully efficient. We obtain an estimate of $effi_h$ for each of the 1,604 hospitals of the sample. The distributions and medians of the estimated $effi_h$ are displayed in Figures 2.4 and 2.5, and in Table 2.4b, by hospital ownership and size.

The efficiency rates derived from the estimation of Model 1 suggest that public hospitals are less efficient than private-for-profit hospitals, whatever their size (Table 2.4b). The difference is sizeable as concerns small hospitals: small public hospitals are amazingly inefficient, with a median efficiency rate equal to 17.2%! The gap between public and private-for-profit hospitals is reduced for medium size hospitals: 64.2% *versus* 80.8%. And it is even smaller for large hospitals, with still a higher efficiency of private FP hospitals: their median efficiency rate is 88.7% while it is 82.4% for large public hospitals. Private nonprofit hospitals of any size show intermediate efficiency rates, but rather close to the performance of for profit hospitals.

As stated above, our empirical strategy consists in examining how the assessment of productive efficiency is modified when regressors describing hospitals' patient and production characteristics are included in the frontier specification. It is quite logical that the introduction of additional regressors to the specification influences efficiency assessment, because it induces a shift in the frontier location. Yet, there is no mechanical reason for the introduction of patient and production characteristics to work in favor of an improvement of the public sector's performance. We know, however, that private-for-profit hospitals are free to select their patients and to choose the hospital services they want to supply. It is likely that their choices as concerns patient selection and supply strategies aim at improving efficiency. If this argument is correct, we should obtain an improvement of public hospital performance when we introduce patient and production characteristics in the frontier specification.

Table 2.4a – Estimation, Second Steps: SCF Model to Identify Inefficiency.

Estimation of the SCF model	Model 1	Model 2	Model 3
asymmetry parameter $\lambda = \sigma_u / \sigma_v$	3.471	2.763	1.222
p-value for the LR test for $\sigma_u = 0$	0.000	0.000	0.000
Coefficient for Teaching	0.649***	0.694***	1.027***

Table 2.4b – Second Step: Median of Estimated Hospital Efficiency Rates $effi_h$

Size	Ownership	Model 1	Model 2	Model 3
Small	Public	17.2	30.2	48.2
	NP	43.6	50.1	64.4
	FP	57.9	57.0	62.9
Medium	Public	64.2	74.9	78.6
	NP	79.4	75.7	78.6
	FP	80.8	80.5	76.3
Large	Public	82.4	85.9	84.5
	NP	87.6	85.5	83.8
	FP	88.7	87.4	81.7

1604 hospitals, 7,731 observations in the hospital-year dimension, period 1998-2003

The efficiency rate, is defined by: $effi_h = \exp(-u_h) = Q_h/Q_h^{max}$

Lecture: *effi* = 82.4 for large public hospitals means that, given the estimated production function, large public hospitals produce only 82.4% of their production capacity.

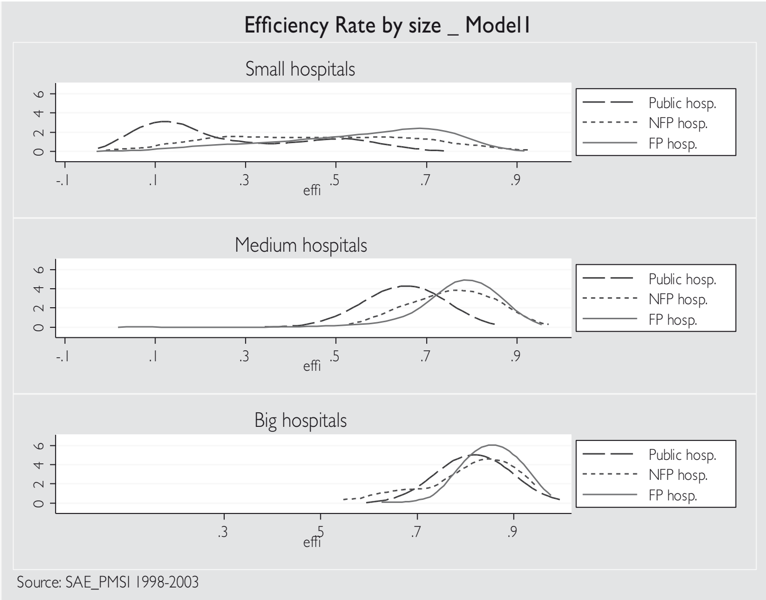

Figure 2.4 – Efficiency Rate Distributions: $effi_h$ Estimated with Model 1.

Indeed, the relative performance of public hospitals is clearly improved when we introduce patient characteristics in the frontier specification (Model 2). The improvement is accentuated when production characteristics are included. According to the results of Model 3, the most efficient hospitals are public hospitals, at least as concerns large and medium sized establishments.[1]

Figures 2.4 and 2.5 display the distributions of the efficiency rates estimated with Model 1 and Model 3. They show that large and medium sized

1. The performance of small public hospitals, though higher than in Model 1, is still very poor. Their median efficiency rate is 48.2% with Model 3.

public hospitals appear to be the most efficient when patient and production characteristics are taken into account, while they appear to be the least efficient when patient and production characteristics are not taken into account.

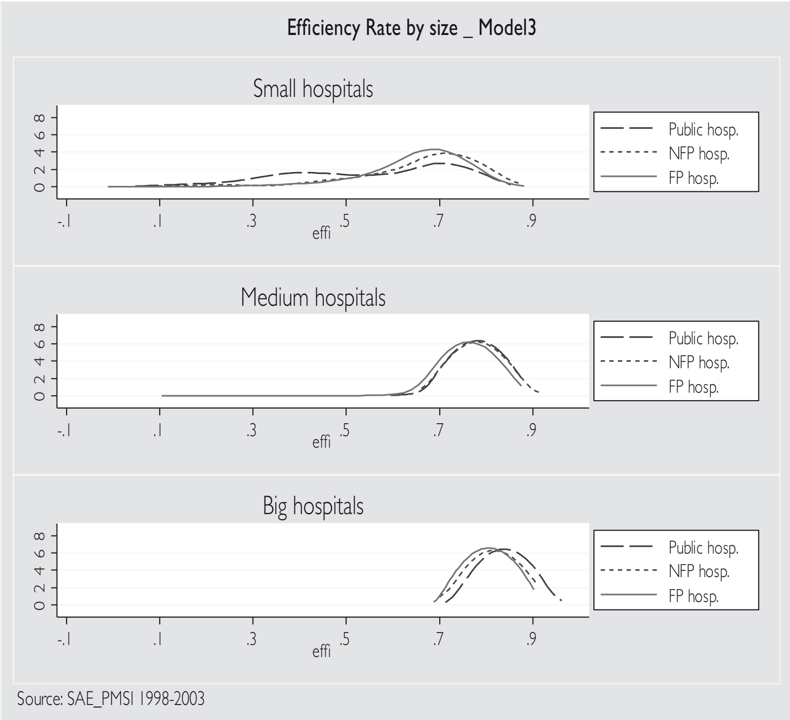

Figure 2.5 – Efficiency Rate Distributions: $effi_h$ Estimated with Model 3.

We have checked the robustness of this result by estimating a Translog production function, and by eliminating teaching hospitals from the sample. We have also estimated the model on a restricted sample of 1,169 hospitals where the number of physicians is observed (in this case, physicians are not treated as an omitted variable). We have also checked the results obtained when very small local or "hybrid" hospitals[1] are eliminated. In any case, we find that public hospitals are more efficient than private-for-profit hospitals when efficiency rates are estimated with Model 3, while the reverse is true when they are estimated with Model 1.[2]

The Sources of Productivity Differences between Public and Private Hospitals

The estimation of the production function makes it possible to evaluate the components of productivity differences between hospitals, depending on their ownership. The use of a Cobb-Douglas specification has the advantage of leading to a formula with additive contributions of inputs, patient and production characteristics.[3] With three types of ownership (public, private-for-profit and nonprofit) and three categories of hospital size, nine combinations can be considered. The results derived from the estimation of Model 3 are displayed in Table 2.5. Results derived from the estimation of Model 1 are given in Table 2.6 in the appendix: they lead to identical conclusions as concerns the impact of production factors.

For large hospitals, the contrasts displayed in Table 2.5, column (c) show that public hospitals are less productive than private-for-profit hospitals: the gap is sizeable, equal to –33.7%. The contributions of production factors to this gap are detailed in Table 2.5, with the resultant line (2). The principal negative effect comes from the number of beds (–38.1%),

1. These hospitals have a non negligible proportion of very long stays, which suggests that they provide long term care in addition to acute care.
2. Tables 2.7 and 2.8a, b in the Appendix provide the results obtained when teaching hospitals are removed from the sample.
3. Actually, the whole two-step estimation procedure is non linear, which causes a non zero residual in the decompositions of table 5.

Table 2.5 – Decomposition of Average Productivity Differences, % (with Model 3)

	Small public – FP (a)	Medium public – FP (b)	Large public – FP (c)	Small public – NP (d)	Medium public – NP (e)	Large public – NP (f)	Small NP – FP (g)	Medium NP – FP (h)	Large NP – FP (i)
Average diff in productivity (to be explained) (1)	**−54.5**	**−33.6**	**−33.7**	**−37.2**	**−26.2**	**−12.7**	**−17.3**	**−7.4**	**−21.0**
Due to :									
Beds	+23.9	−12.4	−38.1	+24.4	+0.5	−16.3	−0.5	−12.9	−21.8
nurses	+9.3	+5.5	+5.5	+4.1	+2.2	+2,1	+5.2	+3.3	+3.4
Nursing aux staff	+9.9	+4.0	+2.8	+7.5	+3.3	+2,1	+2.4	+0.8	+0.7
administrative staff	+10.6	+5.1	+5.4	+3.4	−1.6	−2,0	+7.2	+6.7	+7.4
Support staff	−15.1	−8.4	-–9.1	−7.7	−2.0	−1.8	−7.4	−6.4	−7.3
Total diff due to production factors (2)	**+38.6**	**−6.2**	**−33.6**	**+31.6**	**+2.3**	**−16.1**	**+6.9**	**−8.5**	**−17.5**
Total diff due to patient characteristics (3)	**−25.8**	**−14.1**	**−11.1**	**−19.9**	**−19.1**	**−13.3**	**−6.0**	**+5.0**	**+2.2**
Total diff due to production characteristics (4) (of which % of surgical stays)	**−45.7 (−38.0)**	**−27.5 (−29.0)**	**−29.0 (−25.7)**	**−20.5 (−12.6)**	**−9.4 (−9.0)**	**−8.9 (−6.5)**	**−25.2 (−25.4)**	**−18.1 (−20.0)**	**−20.1 (−19.1)**
Teaching hospital (5)	**+4.4**	**+2.6**	**+23.7**	**+4.4**	**+2.6**	**+23.7**	-	-	-
Unobservable heterogeneity (6)	**−4.7**	**+8.2**	**+14.9**	**−9.3**	**−2.2**	**+3.9**	**+4.6**	**+10.4**	**+10.9**
Inefficiency (7)	**−34.1**	**+2.9**	**+0.7**	**−32.9**	**−1.9**	**−1.0**	**−1.2**	**+4.8**	**+1.7**
Residual* (8)	+13.0	+0.6	+0.7	+9.4	+1.5	−1.1	+3.6	−0.9	+1.9

1,604 hospitals 1998-2003, 7,731 observations. One has : (g) = (a)-(d) ; (h) = (b)- (e); (i) = (c) – (f).

* A residual appears because the two-step estimation procedure is non linear.

which is particularly high in the public sector (see the descriptive analysis above). The excessive number of support staff also has a strong negative influence on public hospital productivity (–9.1%). We have seen that the proportion of support staff is particularly large in public hospitals. As shown by Clark and Milcent (2011), political considerations in connection with the local unemployment rate might influence employment in French public hospitals. In total (line [2]), the resultant of productivity differences due to production factors causes a productivity gap of –33.6% for public hospitals. Patient characteristics also have a negative impact on public hospital productivity (–11.1%), as do production characteristics. The latter explains a 29% gap with respect to private-for-profit hospitals, of which 25.7% are due to the proportion of surgical stays: the specialization of private-for-profit hospitals in surgical stays explains their higher productivity. Conversely, the positive impact of teaching hospitals, hightech establishments which are exclusively public, and the impact of unobserved heterogeneity, work in favor of the productivity of public hospitals. The influence of unobserved heterogeneity is likely to reflect the impact of omitted variables such as the number of doctors, or the existence of economies of scale or scope. Finally, as stated above, differences in productive efficiency work in favour of public hospitals (column c, line 7). However, the impact on the productivity gap of differences in efficiency is very limited: +0.7% only.

Private nonprofit hospitals are not very common in France, unlike the USA. Some people try to promote this type of ownership in France, arguing that it combines flexibility in human resources management, as in the private sector, with an objective function that is compatible with mandates in connection with the public interest (Silber, 2005). Actually, the relative performance of large private nonprofit hospitals with respect to for profit hospitals is about the same as the relative performance of large public hospitals (Table 2.5). The productivity gap is smaller, though still sizeable (–21.0%, see column i).We find that the same factors explain the lower productivity of large nonprofit hospitals: the number of beds, support staff in excess, as well as production composition, characterized by a low proportion of surgical stays. One noticeable result is that patient composition tends to improve productivity of large nonprofit hospitals (+2.2%, line 3, column i), contrary to what we find for public hospitals. To sum up, large nonprofit hospitals appear quite similar to large public hospitals, except that they benefit from an advantageous patient composition. Since they are not allowed to select patients, other mechanisms must be at work. One explanation could lie in specific links between nonprofit hospitals and some complementary health insurance compagnies, resulting in preferential assignment of their enrollees to nonprofit hospitals. Indeed, optional complementary insurance is subscribed to by higher proportion by high income individuals than low income individuals.

These results are confirmed by an examination of medium size hospitals. In this category, private nonprofit and for profit hospitals are quite numerous: 40 nonprofit and 234 for profit hospitals are observed, giving robustness to the conclusions drawn above. The only noticeable difference is that the number of beds in public and nonprofit hospitals has a lower negative impact for medium hospitals: the productivity loss is equal to about 12% (line "beds", columns b and h).

The performance of small public hospitals is very poor, compared to small private-for-profit hospitals: the productivity gap amouts to –54.5%! This gap is explained by patient composition (–25.8%), production characteristics (–45.7%) and high inefficiency (–34.1%) (Table 2.5, column a).

Conclusion

The hospital payment reform of 2004 has introduced yardstick competition to provide incentives for efficiency in care delivery. Convergence of payments was supposed to establish competition mechanisms between public (or nonprofit) and for profit hospitals, in order to reduce their cost differences. The latter might derive from productivity gaps or, for a given level of productivity, from differences in input prices. They can also derive from allocative inefficiency when hospitals do not adjust the input proportion in connection to their relative prices. If hospitals are cost efficient, differences in productivity might result from input price difference between sectors (In France nurses' wages are higher in private than in public hospitals, Aude and Raynaud, 2009). More simply, productivity differences can stem from productive inefficiency, when actual production is below the production frontier.

Focusing on hospital productivity instead of hospital costs amounts to examining only one cause of cost differences between public and private hospitals. However, this approach has two advantages: (i) it makes possible the use of a performance indicator, which is reliable and comparable between private and public hospitals; (ii) contrary to studies on costs, that restrict the analysis to a rather limited hospital subsample, it enables us to use comprehensive administrative data, that represent about 90% of admissions for acute care in France.

We show that the appraisal of productive efficiency depends closely on the production frontier specification. With a classical production function linking inputs to output, the estimated efficiency rates of public hospitals are lower than those of private nonprofit hospitals, which are themselves lower than the efficiency rates of private-for-profit hospitals. This ranking in efficiency is observed whatever the size of the establishments. But this ranking is reversed when the frontier specification includes hospital patient and production characteristics. Except for small establishments, public hospitals then appear to be more efficient than private-for-profit hospitals. Private nonprofit hospitals are also more efficient than for profit hospitals, whatever their size. This result concerning the inversion of the ranking of efficiency rates is particularly robust: it is obtained for several specifications of the production function, whether or not teaching hospitals are included, whether or not physicians are included in the regressors, etc.

These results should be interpreted in the light of the mandates and rules that regulate the activity of public hospitals. It is striking that the ranking in efficiency is reversed when patient and production composition is included in the analysis. Indeed, the structure of activity and patient composition are exogenously given for public hospitals, because they have to provide care in relation to needs and are not allowed to select patients.

Our estimates make it possible to assess the components of the productivity differences by type of hospital ownership. The lower productivity of public hospitals is mainly explained by an excessive number of beds, an excessive number of support staff, as well as patient and production composition (in particular, the small proportion of surgical stays). It is not explained by lower efficiency.[1]

The fact that hospital productivity is influenced by patient and production composition is problematic. As a result, the payment reform is likely to encourage public hospitals to manipulate their patient composition and modify the structure of their supply for care. On the basis of our estimates, they should for instance admit less women aged 80 and increase the proportion of surgical stays. In principle, a payment scheme based on yardstick competititon is an instrument to improve productive efficiency. It is not supposed to influence allocative efficiency. The fee schedule is supposed to reflect costs associated to efficient activity. Tariffs are not supposed to be prices that would reflect the social value, or desirability of a stay in a given DRG. Our results suggest that the production function is such that production composition affects productivity. In this context, a system based on a prospective payment per stay might be harmful to allocative efficiency.

Appendix

See tables.

1. Except for small hospitals.

Table 2.6 – Decomposition of Average Productivity Differences, % (with Model 1)

	Small public – FP (a)	Medium public – FP (b)	Large public – FP (c)	Small public – NP (d)	Medium public – NP (e)	Large public – NP (f)	Small NP – FP (g)	Medium NP – FP (h)	Large NP – FP (i)
Average diff in productivity (to be explained) (1)	**−54.5**	**−33.6**	**−33.7**	**−37.2**	**−26.2**	**−12.7**	**−17.3**	**−7.4**	**−21.0**
Due to :									
Beds	+16.3	−8.5	−26.0	+16.6	+0.3	−11.1	−0.3	−8.8	−14.9
nurses	+13.1	+7.7	+7.7	+5.8	+3.1	+2,9	+7.3	+4.7	+4.8
Nursing aux. staff	+4.1	+1.7	+1.1	+3.1	+1.3	+0.8	+1.0	+0.3	+0.3
administrative staff	+11.8	+5.7	+6.0	+3.8	−1.7	−2,3	+8.0	+7.4	+8.3
Support staff	−17.5	−9.8	−10.6	−9.0	−2.4	−2.1	−8.5	−7.4	−8.5
Total diff due to production factors (2)	**+27.8**	**−3.2**	**−21.7**	**20.3**	**0.6**	**−11.8**	**+7.5**	**−3.8**	**−9.9**
Teaching hospital (5)	**+2.8**	**+1.7**	**+15.0**	**+2.8**	**+1.7**	**+15.0**	**0**	**0**	**0**
Unobservable heterogeneity (6)	**−3.2**	**−10.5**	**−23.6**	**−3.1**	**−10.6**	**−16.1**	**−0.2**	**0.1**	**−7.5**
Inefficiency (7)	**−99.9**	**−22.6**	**−12.3**	**−72.8**	**−20.6**	**−5.1**	**−27.1**	**−2.0**	**−7.3**
Residual* (8)	+18.2	+1.0	+9.0	+15.6	+2.7	+5.3	+2.6	−1.7	+3.7

1,604 hospitals 1998-2003, 7,731 observations. One has : (g) = (a)-(d) ; (h) = (b) − (e); (i) = (c) − (f).

* A residual appears because the two-step estimation procedure is non linear.

Table 2.7 – Estimation Results, First Step. Robustness: Estimation without Teaching Hospitals. Dep. Variable: Log *(production per bed)*

	Model 1	**Model 3**
Log (*bed*)	−0,3287***	−0,4852***
Log (*nurs/ bed*)	0,2937***	0,2108***
Log (*nurs_aux/bed*)	0,0328	0,0976*
Log (*adm staff/bed*)	0,4707***	0,4187***
Log (*support staff/bed*)	−0,3043***	−0,2604***
% women 19-40		0,2542
% men 19-40		0,9248**
% women 41-50		0,0309
% men 41-50 = ref.		–
% women 51-60		−0,0615
% men 51-60		0,3755
% women 61-70		0,7794**
% men 61-70		0,3745
% women 71-80		0,4453
% men 71-80		−0,1212
% women 81-90		−0,7391***
% men 81-90		−0,0918
% women 91 +		−0,0136
% men 91 +		−0,8356
% admissions severity 1= ref.		–
% admissions severity 2		0,8225***
% admissions severity 3		1,6106***
Admission		
another hospital or care *unit= ref.*		–
home		−0,1231**
Discharge		
another hospital or care *unit= ref.*		–
home		−0,0460
other hospital		−0,0725
death		−1,0490***
% stays in CMD 1		−0,1739
% stays in CMD 2		−0,1442
% stays in CMD 3		−0,5621**
% stays in CMD 4		0,7546***
% stays in CMD 5		0,8142***
% stays in CMD 6		1,6991***
% stays in CMD 8		0,4825**
% stays in CMD 14		2,0743***
% stays in CMD 23		0,3651**

	Model 1	Model 3
% stays shorter than 24h) % stays with surgery Specialisation Index Specialisation Intensity		0,7983*** 0,9628*** 0,1887** −0,6530***
R^2	0,99	0,99

1,533 hospitals 1998-2003, 7,479 observations. Specifications include year dummies and hospital fixed effects.
*: significant (10%), **: significant (5%), ***: significant (1%).
MDC 1: nervous system, MDC 2: eye, MDC 3: ear, nose, mouth and throat, MDC 4: respiratory system, MDC 5: circulatory system, MDC 6: digestive System, MDC 8: musculoskeletal system and connective tissue, MDC 14: pregnancy, childbirth and puerperium, MDC 23: factors influencing health status. Specialization index= 1 if the highest proportion of stays in a given MDC is greater than 33%, intensity is equal to the value of the highest proportion of stays in a given MDC, if specialization index = 1 (otherwise it is equal to 0).

Table 2.8a – Checking for Robustness: Estimation Without Teaching Hospitals Estimation, Second Step: SCF Model to Identify Inefficiency

Estimation of the SCF model	Model 1	Model 2	Model 3
asymmetry parameter $\lambda = \sigma_u / \sigma_v$	3.434	2.725	1.127
p-value for the LR test for $\sigma_u = 0$	0.000	0.000	0.000

Table 2.8b – Second Step: Median of Estimated Hospital Efficiency Rates *effi*$_h$

Size	Ownership	Model 1	Model 2	Model 3
Small	Public	18.1	35.5	54.2
	NP	43.9	50.7	66.0
	FP	58.3	57.2	64.5
Medium	Public	64.9	75.4	79.2
	NP	79.5	75.8	79.0
	FP	81.0	80.5	77.0
Large	Public	83.7	87.6	85.5
	NP	87.6	85.6	84.1
	FP	88.8	87.6	82.0

No teaching hospital: 1533 hospitals, 7479 observations in the hospital-year dimension, period 1998-2003
The efficiency rate, is defined by: $effi_h = exp(-u_h) = Q_h/Q_h^{max}$
Lecture: *effi* = 83.7 for large public hospitals : they produce only 83.7% of their production capacity.

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3

Hospital Competition, Quality, and Expenditures in the US Medicare Population

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Abstract

Theoretical models of competition with fixed prices suggest that hospitals should compete by increasing quality of care for diseases with the greatest profitability and demand elasticity. Most empirical evidence regarding hospital competition is limited to heart attacks, which in the US generate positive profit margins but exhibit very low demand elasticity—ambulances usually take patients to the closest (or affiliated) hospital. In this chapter, we derive a theoretically appropriate measure of market concentration in a fixed-price model, and use differential travel-time to hospitals in each of the 306 US regional hospital markets to instrument for market concentration. We then estimate the model using risk-adjusted Medicare data for several different population cohorts: heart attacks (low demand elasticity), hip and knee replacements (high demand elasticity) and dementia patients (low demand elasticity, low or negative profitability). First, we find little correlation within hospitals across quality measures. And second, while we replicate the standard result that greater competition leads to higher quality in some (but not all) measures of heart attack quality, we find essentially no association between competition and quality for what should be the most competitive markets—elective hip and knee replacements. Consistent with the model, competition is associated with lower quality care

among dementia patients, suggesting that competition could induce hospitals to discourage unprofitable patients.[1]

Introduction

The question of how competition affects quality of health care is a topic that has received considerable attention in recent years. Theoretical models imply that when price exceeds marginal cost in a fixed-price regime, hospitals respond by competing for more patients by improving quality (Gaynor and Town, 2012; Gaynor *et al*., 2015). In general, the empirical evidence is mixed on the association between competition and quality, with evidence of positive, negative, and zero associations.[2]

Most studies of competition have used acute myocardial infarction (AMI), or heart attacks, as the representative patient population in measuring hospital quality, but heart attack patients typically exhibit a very low elasticity of demand for hospital treatment—ambulance drivers are usually instructed to bring heart attack patients to the nearest emergency room, or to their affiliated hospital (Doyle *et al*., 2015), since damage to the heart muscle worsens for every minute untreated. Therefore, we would

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2. For excellent discussions of the literature see Gaynor and Town (2012), Gaynor *et al*. (2015), and Brekke *et al*. (2014); Gravelle *et al*. (2012) consider the special case of fixed-price competition which we focus on here. Also see Gravelle *et al*. (2014), Kessler and McClellan (2000), Gowrisankaran and Town (2003), Cooper *et al*., (2011, 2013), Pan *et al*. (2015), Bloom *et al*. (2015), Propper *et al*., (2008), Escarce *et al*., (2006), Rogowski *et al*., (2007), Gaynor *et al*. (2013), Santos *et al*. (2016), Gobillon and Milcent (2016), and Moscelli *et al*. (2016).

not expect improved quality of AMI care to increase demand by much for a given hospital. While quality for one treatment could provide a proxy for quality for other conditions—hospitals with better treatments for AMI may have better hip replacement outcomes—this assumption has been questioned by others (e.g., Skellern, 2015; Bevan and Skellern, 2011). One English study, for example, found little correlation among treatment quality for AMI, stroke, and hip fracture patients (Gravelle *et al*., 2014).

In this chapter, we reconsider the association between competition and outcomes using the entire population of fee-for-service patients in the US Medicare claims data for the years 2010-2011. We first derive a theoretically consistent estimating equation for the relevant case in which hospitals are competing on the basis of quality in a fixed-price regime, such as the US. Medicare program. We find the key summary competition measure in this model is the LOCI (the Logit Competition Index), originally developed by Antwi *et al*. (2013) in a different context for hospitals that compete on prices. We argue that this LOCI approach provides a better characterization of competition compared to the conventional Herfindahl-Hirschman Index (HHI), because it captures the influence of hospital size on competition—that a smaller hospital has proportionately more untapped patients in its spatial market than does a larger or dominant hospital. To adjust for potential endogeneity, we instrument both the LOCI, and hospital volume —a key component of quality—using the Kessler and McClellan (2000) differential distance approach in a multinomial logit choice model for each of 306 US hospital market areas.

We test the standard model by considering a wider range of diseases with either greater demand elasticity or with lower profit (or contribution) margins (Eappen *et al*., 2013). We hypothesize that elective high-margin treatments planned weeks in advance and often sought by otherwise healthy people, such as reproductive technologies (as in Bundorf *et al*., 2009), or in our case, hip and knee replacements (as in Moscelli *et al*., 2016), would exhibit much greater underlying demand elasticity for quality of care, and hence lead to a much sharper quality gradient in competitive markets. Concerns with patient selection issues are addressed by comprehensive risk adjusters, and by the clinical reality that hospitals should not perform elective joint replacements for any patient with a high risk of complications.

We also hypothesize that the association between quality and competition would be different for diseases with lower or even negative profitability, such as advanced dementia requiring extensive nursing and physician inputs. In this case, the theoretical model implies *poorer* quality care for treatments with negative margins in competitive markets, as hospitals have greater incentives to avoid such patients.[1]

Briefly, we find that the association between competition and quality for AMI patients is weakly consistent with the model; more competition is predictive of greater use of appropriate medications (beta blockers and statins) after discharge and, in the least-squares regression, lower 30-day risk-adjusted mortality. As well, risk—and price—adjusted spending is slightly higher in more concentrated markets. However, we find that the association between quality of hip and knee replacements and concentration is minimal. This is inconsistent with the theoretical model of competition, which would predict the strongest association between competition and quality for these procedures.

As in Gravelle *et al*. (2014) and Skellern (2015), we do not find that AMI quality is a good summary "marker" for hospital quality; the correlation coefficient between risk-adjusted AMI mortality and risk-adjusted hip or knee complications is essentially zero. This by itself is not inconsistent with the economic model, since hospitals should compete on quality very differently across clinical departments depending on demand elasticities and profit margins, but it does highlight the limitations of using AMI as a paradigm for hospital competition and quality.

1. Although Brekke *et al*. (2011) discusses the important philanthropic motives of hospital administration and staff that would work against such behavior.

We also consider the likelihood of poor quality in the treatment of dementia patients. Our measure of poor quality is the placement of a feeding tube in the terminal phase of dementia when patients have lost their ability to eat. Feeding tubes for patients with advanced dementia are viewed as a burdensome procedure for the patient, leading to complications and lower quality of life, and thus a marker for poor-quality care (American Geriatrics Society, 2013). For hospitals in the most concentrated markets, poor quality is more pervasive among dementia patients. This result is consistent with the theoretical model in which hospitals pay little attention to quality for treatments with low or even negative margins (e.g., Gaynor and Town, 2012).

In sum, our evidence provides little support for the view that competition *per se* raises quality of care. The weak links in this causal pathway —from measured market concentration to clinical quality—may arise at a variety of points. For example, Bynum *et al*. (2014) suggests that standard models of competition may not be suited to the more complex world of physician referrals, where primary care physicians play a dominant role in referring patients to a specific hospital (Barnett *et al*., 2012). Nor do physicians and patients always have a good idea of which hospitals provide high quality (Schneider and Lieberman, 2001; Goldman and Romley, 2008; Whaley *et al*., 2014; Desai *et al*., 2016, although see Chandra *et al*., 2016, and Santos *et al*., 2016). Finally, the findings based on European data that often support a positive association between competition and quality (e.g., Gaynor *et al*., 2013, Gobillon and Milcent, 2016) could arise because single-payer systems there provide more incentives to compete on quality in a fixed price setting, while Medicare is just one of many insurance providers in the US.

The Model

We begin with the standard model of competition as derived in Gaynor and Town (2012) augmented to include the assumption of fixed prices, as in the Medicare program. We assume the cost function of hospital j

for a specific procedure or treatment, $C_j(x_j,z_j)$ is increasing with respect to both the quantity of services provided, x_j (i.e., the number of procedures or admissions), and the average level of quality z_j provided for patients at that hospital, given the fixed price for Medicare services, $\overline{p}$. Note that $x_j = D(z_j, z_{-j})$ so that demand at hospital j depends on quality at hospital j relative to quality at all other hospitals in the market except j, z_{-j}. This demand function could include both competition among hospitals for a given group of patients, as well as reflecting overall demand for the procedure.[1] However, in our estimation below, we assume a fixed number of total hospital admissions in each ZIP code.

Assuming profit maximization on the part of the provider, where quantity is a function of own-hospital quality z_j and other hospital quality z_{-j}, cost is a function of own-hospital quality and volume x_j, where prices are fixed ($\overline{p}$):

$$\pi_{tj} = \overline{p}D\left(z_j, z_{-j}\right) - C(z_j, x_j) \tag{1}$$

If providers choose their level of quality to maximize profit and there are zero profits in equilibrium (for derivation see the Appendix),

$$\left[\overline{p} - MCx_j\right]\frac{dx_j}{dz_j} = MCz_j \tag{2}$$

The left-hand side of (2) is the incremental profitability from an additional admission to the hospital, times the number of new admissions (x) that would occur if the hospital improved quality (z) by one unit. The right-hand side of (2) is simply the marginal cost of increasing quality by one unit; thus hospitals in this simplified world increase quality to the point where the marginal net revenue is equal to the marginal cost. Note that

1. For example, people in an area with high-quality academic centers could be more likely to undergo a hip replacement (rather than put up with the pain) because their chance of a successful complication-free procedure is greater.

when the contribution margin, or price minus the marginal cost of an extra patient, is small or even negative, hospitals will have a greater incentive to shed patients when demand responds more readily to changes in quality (dx_j / dz_j), as one might expect to observe in more competitive markets.[1] We next turn to a more formal model that characterizes the link between this derivative and the competitive structure of the market.

As in previous studies, we assume a multinomial logit model of patient choice. Let total admissions to all hospitals in ZIP code $t = 1,\ldots,T$ be N_t. In the logistic model, the predicted number of admissions to hospital j, $\hat{x}_j$, is a function also of a hospital ZIP code fixed effect (a_{tj}) reflecting the convenience and perceived desirability of hospital j for residents of ZIP code t, as well as the clinical quality of the hospital (z_j):

$$\hat{x}_j = \sum_{t=1}^{T} N_t \frac{exp\left(\alpha z_j + a_{tj} + \epsilon_{tj}\right)}{\sum_{t'=1}^{T} exp\left(\alpha z_j + a_{t'j} + \epsilon_{t'j}\right)} \tag{3}$$

To uncover the elasticity of demand with respect to quality, we can write the derivative of hospital j's demand with respect to its own quality under the assumption of a fixed-price model. As we demonstrate in the Appendix, with fixed prices the summary measure of competition ends up looking much like the Antwi *et al*. (2013) derivation of what they call the Logit Competition Index, or the LOCI:

$$\frac{d\hat{x}_j \; / \; \hat{x}_j}{dz_j} = \alpha \; \widehat{LOCI}_j \tag{4}$$

1. This equation implies that hospitals will discourage patients for as long as marginal cost exceeds price, regardless of the elasticity of admissions with respect to quality. The marginal costs may also include the high degrees of stress imposed on nurses and physicians because patients with advanced dementia can be so difficult to treat, thus requiring additional staffing, greater employee turnover, or higher wages. A more general model of hospital behavior that includes eleemosynary motives towards patients, however, would attenuate these purely profit-driven incentives to minimize quality (e.g., Gaynor and Town, 2012).

where

$$\widehat{LOCI}_j = \sum_{t=1}^{T} \left(\frac{\hat{x}_{tj}}{\hat{x}_j} \right) \left[1 - \hat{x}_{tj} / N_t \right].$$

Thus the proportional responsiveness of admissions to improving quality depends both on the elasticity of demand with respect to quality, summarized by α, and the LOCI or our measure of competition that holds even when prices are fixed.[1] In practice, we calculate the LOCI that is defined on actual admissions x_{jt}, written as LOCI_j (without a caret). In this case, we'd replace actual admissions to hospital j in ZIP t, x_{tj}, for $\hat{x}_{tj}$, and n_{tj}, the share of hospital j's admissions coming from ZIP code t, for the first term in parentheses. Note that for perfect competition, the LOCI converges to 1, and for a monopoly, it is 0.

For the intuition behind the LOCI, it is useful to compare it with the commonly used Herfindahl-Hirschman Index (HHI). Recall that in our setting using actual rather than estimated values, the HHI would be

$$HHI_j = \sum_{t=1}^{T} n_{tj} \left[\sum_{k=1}^{J} x_{kt}^2 / N_t^2 \right] \tag{5}$$

The HHI is normalized to 1 for a monopoly, and approaching zero for a perfectly competitive market, the opposite of the LOCI.[2] Note that the LOCI captures the fraction of patients in a given hospital's market that are *not* being admitted to the hospital, or the market share that the hospital has to gain. Consider for example a scenario in which a small hospital competes with the larger hospital across the street, and that each hospital drew the same *proportional* number of patients from each ZIP code (n_{tj}). The HHIs for each hospital would therefore be identical, since the weights

1. While in theory, α varies across regions, for simplicity we adopt a single elasticity.
2. For comparability with the LOCI, we report the HHI as ranging from 0 to 1, rather than from 0 to 10,000 as is often done.

would match up, and the ZIP code HHI is the same regardless of which hospital is being considered. By contrast, the LOCI would suggest that the smaller hospital is more competitive, in the sense that it is easier for it to increase proportional capacity when its initial share is so modest. Because it is easier for the small hospital to increase its share, the LOCI theoretically better reflects its incentive to improve quality.

Using equation (2) above, we can write the first-order condition for hospitals competing on quality as:

$$\bar{p} - MCx_j = \frac{MCz_j}{\hat{x}_j LOCI_j} \ . \qquad (6)$$

To estimate the association between quality and competition (as proxied by $LOCI_j$), we consider a Taylor-series approximation of the marginal cost of increasing quality per patient admission:

$$MCz_j \ / \ \hat{x}_j \cong \boldsymbol{\mu}_j + az_j + bx_j \qquad (7)$$

This approximation captures both a rising marginal cost of improving quality ($a > 0$) as well as the degree of proportionality with respect to output. For example, if the hospital provides better quality by hiring more experienced and skilled nursing staff, the marginal cost of that increment will be roughly proportional to the number of admissions (or bed-days); thus $b \sim 0$. If instead quality was more easily attained with greater volume, for example in surgical quality (Birkmeyer *et al*., 2002, 2003; Ho, 2002; Gaynor *et al*., 2005), then it could be that $b < 0$. It's also possible that $b > 0$; the marginal cost of improving quality for dementia patients (for example) may be higher in bigger hospitals because of challenges in coordinating care across a much larger number of employees and post-hospital settings.

By rearranging, we can write

$$z_j = \frac{\left(\bar{p} - MCx_j\right) LOCI_j - bx_j - \boldsymbol{\mu}_j}{a} \qquad (8)$$

Thus quality is dependent on three basic characteristics. First, it is predicted to be higher the greater is the marginal profitability, $\bar{p} - MCx_j$, as noted above.[1] Second, when the marginal profitability is positive, the nearer is the LOCI to perfect competition, the higher is predicted quality of care. Competition also influences hospital behavior by giving a stronger incentive to hospitals with small market share (and thus a larger LOCI) to capture more business from other hospitals in the market. But smaller hospitals may also experience diseconomies in providing high-quality care, for example when $b < 0$, as noted above (or if the coefficient a is higher for smaller hospitals). Finally, Equation (8) implies that volume (x) should be included on the right-hand side of the equation in determining quality. The challenge for estimation is that instruments are required for both volume and for the LOCI (Gaynor, 2006; Gowrisankarajn *et al*., 2008); we address this on page 133.

Clinical Considerations

As noted above, the standard economic model posits that hospitals will compete more vigorously by improving quality in more competitive markets and when the profit margins are greater. We consider next three distinct types of treatments that we know, from prior clinical research, differ substantially along these two dimensions.

First we consider acute myocardial infarction (AMI), which is the most common clinical condition considered in previous studies, beginning with Kessler and McClellan (2000). The onset of an AMI is sudden and patients and ambulances are instructed to go to the nearest hospital (or to their affiliated hospital, as in Doyle *et al*., 2015), because treatment is best if delivered within 90 minutes of symptom onset and requires on-site capabilities

1. Of course, MCx_j is itself endogenous, but we assume that changes in z_j have second-order effects on $\bar{p} - MCx_j$ (and more importantly, that changes in quality do not cause its sign to flip).

that are not present at all hospitals. While previous studies have argued that studying AMI allows researchers to worry less about selection bias (that is, healthier patients may seek out one hospital over another), and that AMI quality signals for other types of hospital quality—a conjecture we test below—the poor opportunity for choice makes the clinical case of AMI less than ideal for studying the relationship between competition and quality.

That said, there are considerable financial gains, as well as potential reputational gains, that can be derived by delivering advanced cardiac care, and these may make hospitals continue to compete in this clinical domain. For example, Robinson (2011) estimated that the average cost of cardiac valve replacement was $38,667, but the contribution margin (price minus average variable cost) was $21,967. And Chandra *et al*. (2016) found evidence showing that hospitals with above-average AMI performance tended to grow in AMI admissions at the expense of their lower-quality rivals.

As an ancillary hypothesis, we consider the association between market concentration and price—and risk—adjusted Medicare reimbursements during the year post-admission. Because we adjust for differences across regions in prices paid by Medicare (largely to capture cost-of-living differences), this measure is best interpreted as an index of utilization. While the theory does not predict whether utilization will rise or fall in response to improving quality—readmission rates might fall in response to better quality, thus reducing one-year utilization—we hypothesize that market concentration should be associated with greater utilization because of substitution effects: To the extent that competition leads to lower prices in the under-65 privately insured markets, this creates a greater incentive to do more for Medicare patients (Glied, 2014).

By contrast, hip and knee joint replacements are elective and planned well in advance which gives the patient opportunity to make informed decisions about where to have the surgery. This clinical situation would seem to fit most closely with any predictions based on the standard model of hospital competition. Furthermore, the profit margins are quite high; one analysis showed average prices to be above even average total cost (and not just marginal cost); see Healy *et al*. (2011). Yet, even for procedures with demonstrated variations in hospital quality, other amenities such as travel time, as in Ho and Pakes's (2014) study of mothers' choices for the choice of obstetric services, could well offset characteristics of the hospital.

One potential shortcoming with hip and knee replacements is the problem of risk-selection; perhaps those seeking a knee replacement at a hospital in a wealthy section of town will be in better underlying health compared to those in a poorer part of town. We address this issue by using hierarchical condition categories (HCC) risk adjustment, which, despite its biases (Song *et al*., 2010), is highly predictive of adverse outcomes.

Clinical cases that are associated with lower margins (or may even represent a loss if beds are at full capacity due to the opportunity cost) may create incentives for hospitals to avoid, rather than compete for, those patients (Anderson *et al*., 2011). People with advanced dementia at the end of life are frequently hospitalized, sometimes repeatedly, in the last months of life. Their hospital stay is not technologically intensive but requires appropriate staffing and can be lengthy, which can present financial problems for hospitals paid a fixed DRG amount. For example, Lyketsos *et al.* (2000) estimate average length of stay equal to 10 days for those with dementia, *versus* 6 days for those without; also see Bynum *et al*. (2004). In addition, these patients may present with symptoms that are difficult to manage (e.g. agitation and confusion), resulting in non-financial costs, such as stress for staff members. Many advanced dementia patients come by ambulance from local nursing homes to the hospital, which attenuates the opportunity for patient or family choice of hospital.

In sum, we hypothesize that the quality of care for these three conditions should exhibit very different patterns of association between quality and market structure. Based on clinical and economic considerations, we would expect a small positive association between quality and competition for AMI patients, a large and positive association for hip and knee replacement patients, and a zero or negative association for dementia patients.

Data

We use the entire fee-for-service Medicare data, centered on 2010-2011, to create five cohorts: one cohort of all-cause hospital admissions (to create concentration indices), and 4 disease cohorts of hospitalized patients: AMI, hip replacements, knee replacements, and dementia patients. The Medicare data files used include MedPAR, Carrier, Outpatient, Hospice, and Home Health.

Medicare Payments System Background

There are two major healthcare models paid for by the Medicare rogram, traditional Medicare and managed care plans operated by commercial payers (Medicare Advantage plans). Traditional Medicare includes Parts A and B and is predominately fee-for-service. Under this plan, doctors and hospitals get paid for each service provided, with little to no oversight on the quantity of services. There are limits on the amounts hospitals and doctors can charge, however. One example is the prospective payment system for inpatient care, where hospitals are paid a relatively fixed amount for each diagnostic related group. In traditional Medicare, Medicare pays a proportion of fees and the beneficiary is responsible for the remainder, called a coinsurance, which is often paid by a supplemental private insurance program (called a "Medigap" plan) or under the Medicaid program for low-income recipients.

The other major healthcare model is managed care; for Medicare this is referred to as Medicare Advantage. Managed care organizations supervise the financing of medical care delivered. Typically, members have limited options for where they can receive their care and there may be capitation, which means doctors are paid per enrollee, regardless of the amount and type of care provided. Owing to this system, individual services provided are not billed separately; thus, we do not have claims pertaining to each service, so we limit our attention to the fee-for-service population only.[1] If individuals with Medicare Advantage exhibit the same admission patterns as those in the fee-for-service population, then our measures of the LOCI will not be affected, although our volume estimates will be systematically too low. Biases in the LOCI will be introduced if those with Medicare Advantage go to systematically different hospitals.[2]

Hospital Admission Cohort and Competition Measures

To measure competition, we require information about the location of where each patient lives and to which hospital they were admitted. We created a cohort of all hospital admissions during 2010-2011 in the fee-for-service Medicare population over age 65, with more than 20 million separate admissions, along with the ZIP code of residence and the first hospital admission. We removed "tourists" living in one hospital region, but admitted to a distant hospital outside of the region, in this analysis.[3]

To create the concentration measure, we sum across the ZIP codes from which patients are admitted to a given hospital (N_t is the number of admissions from ZIP code t) and calculate $S_{t \rightarrow j}$ as the share of admissions in ZIP code t to hospital j. We then calculate a weighted average across ZIP codes from which the hospital admits patients, where the weights are

1. Medicare tries to collect encounter data for the managed care population, but has not yet issued such data for researchers.

2. In Medicare Advantage, there is also likely less competition by hospitals for patients, but more competition to be included in insurance-based hospital networks.

3. One could argue that disease-specific measures of competition are more appropriate. However, Skellern (2015) found that the disease-specific concentration measures in England were highly correlated with the overall concentration measure.

the percentage of the hospital's all-cause admissions from each ZIP code. As noted above, the LOCI index depends on the fraction of the ZIP code market *not* admitted to hospital *j*, and therefore represents the potential market for that hospital.

We also created a ZIP code level HHI for each hospital *j*. The hospital-specific HHI was created by taking a weighted average of the ZIP code-level HHI, where the weights were (as above) the fraction of patients admitted to hospital *j* who live in ZIP code *t*.

Four Disease Cohorts

We created cohorts of fee-for-service Medicare patients at least 66 years of age (to allow for one year of observation prior to admission) with eligibility for Medicare Parts A and B and no HMO coverage in the study window. Patients must be hospitalized for 1) AMI; 2) total hip replacement; 3) total knee replacement; and 4) dementia (in the six months before death) in 2010-2011.[1]

For AMI patients, we require the primary diagnosis code to be 410.x1 or 410.x2. The beneficiary is assigned to the admitting hospital, regardless of whether they were later transferred to another hospital.

For total knee replacement patients, we require a hospitalization with the procedure code for total knee replacement 81.54 and any diagnostic codes 715.09, 715.16, 715.26, 715.36, 715.89, 715.96. For total hip replacement, we similarly require a hospitalization with the procedure code for total hip replacement 81.51 and any diagnostic codes 715.09, 715.15, 715.25, 715.35, 715.89, 715.95. For both the hip and knee replacement cohorts we exclude patients with cancer, infections, congenital anomalies,

1. AMI patients are ≥ 66 years of age, hip and knee replacement patients are ≥ 66 years of age to allow for one year of observation for the HCC scores and HMO coverage. AMI patients are excluded if they have HMO coverage within one year of the heart attack.

fractures and dislocations from injuries and accidents, or failure of orthopedic devices.

For dementia patients, we require one claim in MedPAR (acute care hospital, critical access hospital, or skilled nursing facility), Hospice, Home Health, or evaluation and management claim in the Carrier file for one of the following diagnostic codes during 2010: 331.0, 331.1, 331.11, 331.19, 331.2, 331.7, 331.82, 290.0, 290.1, 290.10, 290.11, 290.12, 290.13, 290.20, 290.21, or 290.3. To qualify for the dementia decedent cohort, the beneficiary must die in 2011 and be hospitalized in the 6 months prior to death.

Patient Characteristics

Patient demographics for the three disease cohorts include age at time of index hospitalization, sex, race/ethnicity (white, black, Hispanic, other), and Rural Urban Commuting Area Codes (RUCA) category (urban, suburban, large town, rural) from the Medicare Denominator file. We also calculate the Hierarchical Condition Categories (HCC) score based on claims in the year before hospitalization (hip and knee replacement cohorts) or death (dementia cohort) and create quintiles of the mean HCC score in the cohort to allow for non-linearities. From the Census and American Community Survey (2010) we measure the percentage in poverty and mean income in each patient's ZIP code.

Quality Outcomes

For AMI patients, we calculate the following outcome measures: 30-day mortality, proportion of patients receiving a beta blocker, proportion of patients receiving a statin, and 30-day spending. We calculate the percent of patients discharged after an AMI that fill a beta-blocker and statin prescription within 6 months (not risk adjusted because all patients should receive these treatments; Munson and Morden, 2013). Finally, we consider risk and price-adjusted total spending in the first year post-admission (Gottlieb *et al*., 2010), which are logged in the regression specification. To risk adjust mortality and spending, we adjust for age and sex of the beneficiary (<69, 70-74,75-79,80-84,85-89,90-99), race/ethnicity of the beneficiary (Black, Native American, Hispanic, Asian, White, other) along with presence of vascular disease, pulmonary disease, asthma, dementia, diabetes, liver and renal disorders, cancer, and the location of the AMI in the heart (ST-elevated MIs, which correspond to anterolateral, anterior wall, inferolateral, inferior wall, infero-posterolateral, true posterior, non-ST-elevated MIs, or subendocardial, and not otherwise specified).

For total hip replacement (THR) and total knee replacement (TKR) cohorts, we measure risk-adjusted 30-day readmission to any acute care or critical access hospital after discharge for any reason and any complication (medical or surgical). Surgical complications include postoperative deep venous thrombosis or pulmonary embolism, postoperative hemorrhage, postoperative surgical site infection, surgical site bleeding, or mechanical complications. Medical complications include postoperative pulmonary failure, postoperative pneumonia, postoperative myocardial infarction, postoperative acute renal failure, or postoperative gastrointestinal hemorrhage. We risk adjust the complication and readmission rates using race, sex, and HCCs.

For dementia patients, we measure feeding tube placement in the last 6 months or life and whether the patient had a burdensome transition in the last three months of life. We risk adjust using sex, race, and HCCs. Feeding tube placement is identified by procedure codes in Carrier file claims (43750, 43246, 44372, 44373, 74350, 43832, 43830, 43653, 49440, 49441, or 49446).

Hospital-Level Variables

To calculate the competition measures, we require that each hospital have at least 1000 total admissions during the 2 years of analysis (*N* = 2,638); this rules out smaller hospitals. In the cohort-specific regressions, we also require each hospital to have at least 10 admissions per cohort (AMI, hip, knee, and dementia); this restricts the sample further to 1,376 hospitals. We create measures of the fraction female, the fraction of each race/ethnicity, and the fraction living in poverty at the ZIP code level (weighted as described above).

Volume (for both the hospital and the surgeon performing the procedure) is well understood to be important for quality across many surgical procedures (Ho, 2002; Gaynor *et al*., 2006; Birkmeyer *et al*., 2002, 2003). Because competition measures are often closely associated with volume, as noted above—small hospitals almost by definition have many more potential patients in a given region than larger hospitals—we independently adjust for surgical volume using the (Medicare) number of AMI, total hip replacements, total knee replacements, and dementia patients in our cohort admitted during the study period; these in turn are instrumented using total predicted volume (described below). From the Provider of Service File and the AHA file we obtain hospital teaching status (Council of Teaching Hospitals member or not) and ownership status (not-for-profit, for-profit, government) of the hospital.

Empirical Specification

We use both least squares regressions and a two stage linear instrumental variables model to explore the relationship between competition and risk-adjusted quality at the hospital level.[1] The key explanatory variable in each model is a measure of the competition facing each hospital, as measured by the LOCI. Of course, the obvious endogeneity issues, both with regard to the competition measure and volume—since better quality could lead to both greater market share and volume—require instrumental variables for consistent estimation.

1. We do not weight by patient volume because our unit of analysis is the hospital and its behavior, not patient behavior. However, weighted regressions yield similar results.

Instrumental Variables

We presume that the quality of the hospital could potentially influence the hospital's market share as well as facility-level volume for a given procedure or patient cohort. For this reason, we use the Kessler and McClellan (2000) instrument for hospital admissions that depends *only* on the differential distance—or in our case, travel-time—to the hospital.

$$x_j^* = \sum_{t=1}^{T} N_t \bar{q}_t \frac{exp\left(d_{tj} + \epsilon_{tj}\right)}{\sum_{j=1}^{J} exp\left(d_{tj} + \epsilon_{tj}\right)} \tag{9}$$

where d_{tj} is the travel time from ZIP code t to hospital j. (This is identical to the specification above in Equation 3, except that the ZIP— and hospital—specific term that depends on quality of care is removed.)[1] Note that this estimation model provides ZIP-level estimates of admissions to hospital j (which can be used to calculate a predicted LOCI), but also provides an estimate of admissions (or volume) at hospital j, x_j^*, that can be used as an instrument for volume. Thus we have two separate instruments (predicted LOCI and predicted volume) for our two separate potentially endogenous variables (actual LOCI and actual total admissions).[2] In practice we use predicted total volume as an instrument for the procedure-specific volume measures in the AMI, hip replacement, knee replacement, and dementia cohorts.

1. One could also include additional variables capturing differential travel effects for specific ages or genders, but this is a fairly homogeneous group; everyone is age 65 or over, and we needed to keep the estimation model simple given the large number of distinct hospitals in many regions.
2. Recall that the predicted LOCI for hospital j depends on more than the predicted volume for hospital j, but also on predicted volumes for other hospitals in the market. Thus these two measures are quite distinct, although they are based on the same first-stage regression; their correlation coefficient is -0.05.

To capture market structure, we include hospitals with at least 1000 admissions in the fee-for-service Medicare population during 2010-11 (N = 2,638). We consider market structure within each of 305 hospital referral regions (HRRs) defined by the Dartmouth Atlas project, excluding Los Angeles. With more than 80 hospitals, the Los Angeles HRR logistics regression did not convergence, so we used the slightly smaller Los Angeles hospital service area (HSA) instead. Thus we have 306 hospital market regions, covering nearly all of the United States.

We draw on methods described in Bekelis *et al*. (2016) using street-level network data from ESRI's StreetMap North America v10.2 (2009 data) and ArcGIS software with the Network Analyst extension, to estimate optimal driving distance from each ZIP code centroid to each regional hospital.[1] We then estimated, for each of the 305 HRRs (and the Los Angeles HSA), a multinomial logistic regression that expressed the likelihood of admission to hospital j based solely on the differential driving time from ZIP t to hospital j, conditional on driving times to all other hospitals in the market.[2]

We include additional variables in our regression that could affect quality of care, for example whether the hospital is for-profit or government, or the share of patients who are African-American, Hispanic, and the average ZIP code poverty rate of hospital patients. A key concern with measures of market concentration is that they may proxy for population density; urban areas tend to exhibit a greater absolute number of hospitals and so exhibit greater degrees of competition. If patients benefit from being nearer to hospitals, rather than competition per se, then we might falsely conclude that competition improves quality (Gravelle *et al*., 2012). We therefore include as exogenous control variables the fraction of patients from rural,

1. Due to the limited street network data in Alaska and Hawaii, driving times there were based on geodesic distances between the origin and destination centroids.
2. While the multinomial logistic model follows from the theoretical choice model, one could also use conditional logit models by HRR.

small city, suburb, and large city regions using rural-urban commuting area measures (RUCAs).

The instruments are highly predictive in the first stages of the IV estimates; as expected, differential driving times strongly predict hospital choice.[1] The partial F-statistic for predicted LOCI (based only on differential driving time) in the LOCI equation is 2,008, while the corresponding partial F-statistic for predicted total volume in the separate cohort-specific volume first-stage estimates exceeds 350 for all IV regressions.

Results

Measuring Market Structure

We first show the distribution of LOCI and HHI across the 2,638 hospitals in the United States in Figure 3.1. There is a wide range of hospital-level competition, ranging from near-perfect competition (with a value of 1) to a more competitive environment (with a value of 0.2). Smaller hospitals tended to exhibit measures of LOCI closer to 1.0 (as they are better able to proportionately expand capacity), but large New York City hospitals (e.g., New York Presbyterian, Mount Sinai, NYU) range between 0.76 and 0.91 as well, reflecting the highly competitive New York market. At the other end of the spectrum, larger hospitals serving rural areas (e.g., Champlain Valley, Vermont; Lynchburg, Virginia; Western Maryland) tend to exhibit LOCI values between 0.2 and 0.3. Figure 3.1 also demonstrates the association between the LOCI and the HHI. Despite the different construction inherent for each measure, there is a strong (negative) association between the two. (Recall that for the HHI, 1 is perfect monopoly and 0 perfect competition, the opposite of the LOCI.)

1. Of the 2,658 hospitals in this larger sample, 7 exhibited predicted volumes that were less than 100 admissions for a variety of numerical optimizing algorithms. (In one HRR, we switched algorithms to achieve convergence.) However, none of these "outlier" hospitals ended up in the sample of 1,376 ultimately used in the data analysis.

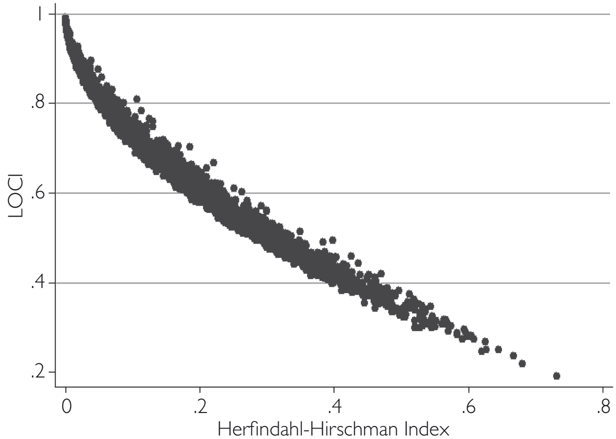

Figure 3.1 – Comparison of LOCI and HHI Measures of Competition, by Hospital ($N = 2{,}638$).

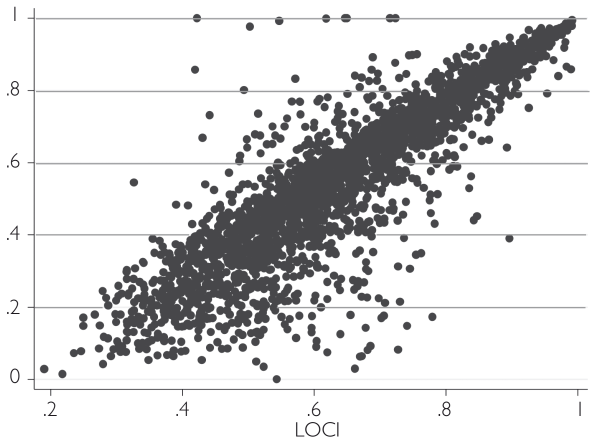

Figure 3.2 – Association between Predicted and Actual Measures of LOCI ($N = 2{,}638$).

We also show the association between predicted and actual LOCI in Figure 3.2. As was mentioned above, predicted LOCI is a very strong predictor of actual LOCI. Figure 3.3 shows predicted and actual volume measures, which again show a very close correlation.

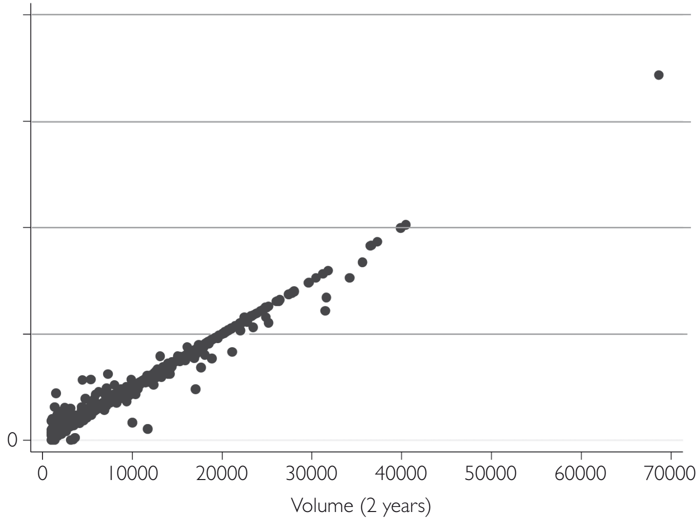

Figure 3.3 – Association between Predicted and Actual Measures of Hospital Volume (any Admission) (*N* = 2,638).

There is a clear outlier hospital in Figure 3.3, with much higher 2-year volumes than the other hospitals. This is the Florida Hospital in Orlando, which (according to *Becker's Hospital Review*) is also the largest hospital in America, with 2,382 beds.[1] That New York Presbyterian hospital, which is second-largest but has nearly identical beds in 2015 (2,373), has far fewer

1. *http://www.beckershospitalreview.com/lists/50-largest-hospitals-in-america-2015.html*

admissions in our data likely reflects Florida Hospital's larger population of over-65 patients, and a smaller share of elderly patients in Medicare Advantage, the managed care option, and thus not present in our sample.

For our regression analysis, we limit the number of hospitals to those with at least 10 admissions for AMI, hip replacement, knee replacement, and dementia during our study period (*N* = 1,376 hospitals). On average, the sample hospitals had 9,959 admissions during 2010-11 (Table 3.1), or a total of 13.7 million admissions underlying the hospital-level sample. The average LOCI competition measure is 0.62 with a standard deviation of 0.16, while the average HHI is 0.22, with a similar standard deviation (0.15).

Table 3.1 – Characteristics of Hospitals (*N* = 1.376)

Hospital characteristics	Mean	Std. Dev.
Number of admissions per hospital	9,959	6,699
Fraction African-American	0.090	0.110
Fraction Hispanic	0.042	0.084
Fraction in poverty	0.098	0.038
Fraction of hospitals with teaching status	0.110	0.311
Logit Competition Index (LOCI)	0.620	0.161
Predicted LOCI based on driving time to hospital	0.522	0.221
Herfindahl-Hirschman Index (HHI)	0.216	0.148
Fraction of patients in urban area	0.622	0.329
Fraction of patients in suburban area	0.113	0.135
Fraction of patients in large town area	0.126	0.231
Fraction of patients in rural area	0.139	0.173

Notes: Unweighted means. Sample comprises all hospitals in the 306 HRRs (except for Los Angeles, which is limited to the the Hospital Service Area) with at least 10 admissions in each of the 4 cohorts: AMI, hip replacements, knee replacements, and dementia.

Turning next to the cohorts, on average, each of the 1,376 hospitals admitted 96.5 patients for AMI during our study period, and provided beta blockers to 83.8 percent, and statins to 75.9 percent of patients in the first 6 months (Table 3.2). The standard deviation for age across hospitals was 2.2; hospitals do not differ substantially with regard to the average age of

Table 3.2 – Characteristics of Hospital-Level Admission Cohorts

Acute Myocardial Infarction Cohort	**Mean**	**Std. Dev.**
Number of AMI patients admitted per hospital	96.5	75.5
Mean age of AMI patients	78.8	2.2
Fraction of AMI patients who are black	0.075	0.111
Fraction of AMI patients who are female	0.500	0.086
Fraction of patients who received a beta blocker within 6 months post-AMI	0.838	0.136
Fraction of patients who received a statin within 6 months post-AMI	0.759	0.164
Risk-adjusted mortality 1 year post-AMI	0.320	0.071
Risk-adjusted mortality 30 days post-AMI	0.148	0.057
Risk- and price-adjusted spending within 1 year post-AMI	$44,083	$7,823
Total Hip Replacement Cohort		
Number of total hip replacement patients admitted per hospital	43.8	39.0
Mean age of admitted total hip replacement patients	75.3	1.4
Fraction African-American	0.051	0.090
Fraction female	0.629	0.095
Fraction with medical complications	0.059	0.053
Fraction with surgical complications	0.047	0.047
Fraction with any complications	0.097	0.066
Mortality 30 days post-total hip replacement	0.003	0.001
Total Knee Replacement Cohort		
Number of total knee replacement patients admitted per hospital	107.3	86.9
Mean age of admitted total knee replacement patients	74.5	1.0
Fraction admitted African-American	0.057	0.092
Fraction admitted female	0.647	0.070
Fraction admitted with medical complications	0.056	0.039
Fraction admitted with surgical complications	0.038	0.032
Fraction admitted with any complications	0.088	0.049
Mortality 30 days post-total knee replacement	0.003	0.007
Deceased Dementia Cohort		
Number of dementia patients admitted per hospital	68.6	48.6
Mean age of admitted sementia patients	85.4	1.4
Fraction admitted dementia patients black	0.094	0.131
Fraction admitted sementia patients female	0.616	0.084
Fraction admitted dementia patients with 1+ burdensome transition	0.210	0.083
Fraction admitted dementia patients with feeding tube placement	0.062	0.056

Notes: Unweighted means by hospital (*N* = 1,376) their patients. Risk-adjusted mortality rates following admission for AMI were 14.8 percent in the first 30 days and 32.0 percent in the first year after admission, while Medicare price-adjusted spending for these patients totaled $44,083 during the first year post-AMI.

The hip and knee replacement cohorts were 75.3 and 74.5 years old, respectively, on average, and had very low 30-day mortality rates (0.3 percent for both knee and hip replacement). Volume (averaged over the 1,376 hospitals) was 43.8 patients for hip replacements, and 107.3 knee replacements. On average, 9.7 percent of hip replacement patients, and 8.8 percent of knee replacement patients, experienced either medical or surgical complications following the procedure.[1]

Our sample of hospitals had 68.6 admissions during our study period on average for dementia patients in the last six months of life. The mean age of these patients was older than the other cohorts (85.4 years), 61.4 percent were women, and 9.4 percent were African-American. During this period, 6.2 percent had a feeding tube, but with considerable variability across hospitals; the standard deviation was 5.6 percent.

Correlation of quality measures across study cohorts

As shown in Table 3.3, there is a surprisingly modest correlation in quality measures across clinical departments in hospitals—cardiology (for AMI), orthopedic (for hips and knees), and hospitalist/general internal medicine, or geriatrics (for feeding tube placement), a result others have found (e.g., Bevan and Skellern, 2011; Skellern, 2015; Gravelle *et al*., 2014).

Within clinical departments, the correlations are higher; the correlation between knee and hip replacement complication rates, for example, is 0.285 ($p < .001$), while for beta blockers and statins, it is 0.210 ($p < .001$).

1. The surgical complication rate, and the medical complication rate, do not add up to the "medical or surgical complication" rate because a few patients experienced both kinds of complications.

Table 3.3 – Correlation of Quality Measures Across Study Cohorts

		AMI			Hip Replacement	Knee Replacement
		Risk-adjusted Mortality	Beta blockers	Statins	Risk-adjusted Any complications	Risk-adjusted Any complications
AMI						
Beta blockers	Corr coeff	−0.0064				
	P-value	0.81				
Statins	Corr coeff	−0.1151	0.2101			
	P-value	<0.001	<0.001			
Hip Replacement						
Any complications	Corr coeff	−0.0010	0.0211	−0.0482		
	P-value	0.97	0.43	0.07		
Knee Replacement						
Any complications	Corr coeff	−0.0542	0.0343	0.0070	0.2851	
	P-value	0.04	0.18	0.80	<0.001	
Dementia						
Feeding tube placement	Corr coeff	−0.0001	−0.0477	−0.0094	0.1169	0.1626
	P-value	0.99	0.08	0.73	<0.001	<0.001

Association of AMI Quality with Market Power

In accordance with previous studies (e.g. Kessler and McClellan, 2000), greater competition is, in some equations, associated with better outcomes in the AMI cohort (Table 3.4a). The coefficient on LOCI in the simple bivariate regression is -0.021 (t-statistic 2.21), implying that a two-standard-deviation shift in the LOCI would reduce mortality by 0.67 percentage points (on an average of 14.8 percent). Model 2 replaces LOCI with the HHI, and suggests the same beneficial effects of competition, but the estimate is not statistically significant. Results for Models 3 and the fully specified 30-day mortality regression in Table 3.4a (Model 4) are similar, with a coefficient on the LOCI of -0.026 (t-statistic of 2.40). The beneficial effects of competition, however, are not found in the IV model; the fully specified equation yields a coefficient of -0.009, with a t-statistic of 0.67. In both the OLS and IV specifications, log volume is estimated to be strongly associated with lower mortality.

Table 3.4a – Relationship between Competition Measures and Risk-Adjusted 30 Day Mortality Following Acute Myocardial Infarction

	Model 1 OLS	**Model 2** OLS	**Model 3** OLS	**Model 4** OLS	**Model 5** IV	**Model 6** IV	**Model 7** IV
LOCI	−0.021		−0.018	−0.026	0.016	−0.002	−0.009
	(2.21)		(1.78)	(2.40)	(1.37)	(0.16)	(0.67)
HHI		0.015					
		(1.55)					
Fraction suburban			0.004	0.002	0.016	0.008	0.005
			(0.26)	(0.12)	(1.15)	(0.55)	(0.35)
Fraction large town			0.022	0.017	0.040	0.028	0.022
			(2.17)	(1.57)	(3.60)	(2.59)	(1.97)
Rural			−0.003	−0.008	0.009	0.001	−0.005
			(0.22)	(0.61)	(0.75)	(0.04)	(0.39)
Log AMI volume			−0.014	−0.015		−0.012	−0.013
			(5.44)	(5.46)		(4.23)	(3.93)
Fraction Black				0.021			0.018
				(1.32)			(1.13)
Fraction Hispanic				−0.022			−0.023
				(1.04)			(1.10)
Fraction poverty				0.101			0.097
				(1.94)			(1.87)
Teaching hospital				0.001			−0.003
				(0.15)			(0.65)
Not-for-profit hospital				−0.009			−0.008
				(1.88)			(1.78)
Government hospital				0.001			0.002
				(0.12)			(0.34)
Constant	0.161	0.145	0.218	0.223	0.130	0.198	0.201
	(27.39)	(52.71)	(15.04)	(13.71)	(15.59)	(11.56)	(10.29)

Table 3.4b – Relationship between Competition and AMI Cohort Quality and Spending Measures

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Dep. Var	Beta blocker		Statins		1-year spending	
	OLS	IV	OLS	IV	OLS	IV
LOCI	0.024	0.087	0.073	0.131	0.089	0.102
	(0.88)	(2.39)	(2.26)	(3.03)	(2.75)	(2.39)
Fraction suburban	0.058	0.073	0.018	0.032	0.007	0.018
	(2.02)	(2.51)	(0.52)	(0.94)	(0.21)	(0.51)
Fraction large town	−0.001	0.025	−0.026	0.0004	−0.091	−0.064
	(0.06)	(1.18)	(1.14)	(0.02)	(3.99)	(2.59)
Rural	−0.013	0.006	−0.104	−0.084	−0.133	−0.104
	(0.51)	(0.25)	(3.51)	(2.76)	(4.52)	(3.48)
Fraction Black	−0.008	−0.016	−0.033	−0.039	0.341	0.351
	(0.19)	(0.38)	(0.66)	(0.78)	(6.85)	(7.17)
Fraction Hispanic	−0.067	−0.065	0.010	0.014	0.359	0.382
	(1.32)	(1.28)	(0.15)	(0.22)	(5.92)	(6.43)
Fraction poverty	−0.024	−0.075	−0.077	−0.138	0.335	0.212
	(0.18)	(0.57)	(0.50)	(0.89)	(2.16)	(1.38)
Teaching hospital	0.028	0.010	0.054	0.035	0.027	0.005
	(2.24)	(0.70)	(3.60)	(2.10)	(1.81)	(0.32)
Not-for-profit hospital	0.007	0.006	0.014	0.011	-0.018	−0.027
	(0.68)	(0.59)	(1.05)	(0.89)	(1.39)	(2.17)
Government hospital	−0.005	−0.001	0.014	0.016	−0.031	−0.035
	(0.31)	(0.09)	(0.77)	(0.91)	(1.73)	(1.97)
Log AMI volume		0.021		0.024		0.041
		(3.00)		(2.86)		(4.83)
Constant	0.817	0.686	0.722	0.584	10.587	10.417
	−33.26	−13.76	−24.69	−9.86	−362.55	−178.51

We consider additional measures for AMI quality, and costs, in Table 3.4b. More competitive markets were associated with greater use of beta blockers in both the OLS and IV specification, as were statins; indeed, the coefficients were larger in magnitude for the IV specification. For example, a two-standard-deviation increase in the LOCI is predicted to improve statin adherence by 4.2 percentage points (on an average of 75.9 percent). Log one-year Medicare expenditures are also predicted to rise in more competitive markets, but not by much. A two-standard-deviation increase in the LOCI is predicted to increase spending by a modest 2.8 percent (in the OLS) or 3.3 percent (in the IV). This holds even after adjusting for the fraction African-American and Hispanic in hospitals.

Association of Hip and Knee Replacement Quality with Competition

In contrast with the AMI cohort, there does not appear to be a consistent association between LOCI and rates of complications among hip and knee replacements. For hip replacements, there is essentially no association between our LOCI competition measure and rates of complications after hip replacements (Table 3.4c). The greater preponderance of negative coefficients for knee replacements (Table 3.4d) is consistent with theory, but only the fully specified IV regression (Model 6) exhibits a marginally significant estimate (coefficient –2.45, p-value 0.044). Procedure volume is strongly predictive of better quality in the least-squares regressions in Tables 3.4c and 3.4d, but these results do not persist when procedure-specific volume is instrumented by total hospital volume.[1]

1. These coefficient patterns are consistent with a model in which some hospitals specialize in hip and knee replacements (reflected in their high volume), but this specialization would not be captured by the instrument—overall predicted hospital admissions. See Chandra *et al*. (2016).

Table 3.4c – Relationship between Competition and any Complication after Hip Replacement

	Model 1 OLS	Model 2 OLS	Model 3 OLS	Model 4 OLS	Model 5 IV	Model 6 IV
LOCI	1.867	1.533	0.344	2.113	2.301	1.114
	(1.52)	(1.26)	(0.27)	(1.49)	(1.57)	(0.72)
Fraction suburban	1.896	1.239	1.470	1.950	2.227	2.473
	(1.09)	(0.71)	(0.83)	(1.12)	(1.28)	(1.36)
Fraction large town	−1.207	−1.900	−1.650	−1.141	−0.794	−0.646
	(1.27)	(1.96)	(1.59)	(1.18)	(0.76)	(0.59)
Rural	−1.628	−2.084	−1.304	−1.593	−1.366	−0.578
	(1.35)	(1.73)	(0.97)	(1.31)	(1.10)	(0.42)
Log hip repl. volume		−1.025	−0.912		0.503	0.609
		(4.14)	(3.44)		(1.02)	(1.15)
Fraction Black			4.077			4.747
			(1.99)			(2.31)
Fraction Hispanic			2.570			3.824
			(0.94)			(1.35)
Fraction poverty			−3.507			−1.270
			(0.52)			(0.19)
Teaching hospital			0.499			−0.273
			(0.93)			(0.47)
Not-for-profit hospital			−1.120			−1.494
			(1.91)			(2.46)
Government hospital			−0.847			−0.944
			(1.10)			(1.20)
Constant	8.73	12.74	13.654	8.558	6.575	7.568
	(9.63)	(9.62)	(8.89)	(8.31)	(2.84)	(2.95)

Table 3.4d – Relationship between Competition and any Complication after Knee Replacement

	Model 1 OLS	Model 2 OLS	Model 3 OLS	Model 4 OLS	Model 5 IV	Model 6 IV
LOCI	0.584	−0.070	−1.255	−0.867	−0.817	−2.45
	(0.64)	(0.08)	(1.31)	(0.83)	(0.76)	(2.02)
Fraction suburban	−0.119	−0.490	−0.210	−0.437	−0.400	−0.246
	(0.12)	(0.49)	(0.21)	(0.43)	(0.39)	(0.23)
Fraction large town	−1.610	−2.238	−2.213	−2.006	−1.941	−2.124
	(2.45)	(3.45)	(3.27)	(2.99)	(2.77)	(2.89)
Rural	−2.626	−3.002	−2.945	−2.831	−2.791	−2.730
	(3.29)	(3.82)	(3.40)	(3.53)	(3.43)	(2.88)
Log knee repl. volume		−1.338	−1.413		0.146	−0.363
		(7.40)	(7.75)		(0.40)	(0.98)
Fraction Black			3.666			4.263
			(2.50)			(2.84)
Fraction Hispanic			−1.535			−0.790
			(0.86)			(0.33)
Fraction poverty			2.398			2.049
			(0.52)			(0.43)
Teaching hospital			1.247			1.194
			(2.81)			(2.65)
Not-for-profit hospital			0.138			−0.194
			(0.36)			(0.49)
Government hospital			−0.348			−0.572
			(0.65)			(1.03)
Constant	9.017	15.500	15.819	10.035	9.338	12.116
	(13.40)	(14.13)	(13.01)	(13.20)	(4.67)	(5.69)

Association of Dementia Patient Quality with Competition

For dementia, the likelihood of both feeding tube placement and burdensome transitions in patients with severe dementia are substantially greater in more competitive markets (Table 3.4e). The coefficient for the fully specified OLS model, which implies a two-standard-deviation increase in the LOCI leading to a 1.4 percentage point increase in feeding tube placement (on an average of 6.2 percent), with a similar estimate in the IV specification without the full set of covariates (Table 3.4e, Model 6). However, the fully specified IV estimate is smaller in magnitude, with a coefficient of 2.12 and only marginal significance (t-statistic of 1.83). As well, volume is positively associated with the use of feeding tubes, suggesting poor coordination of care in larger hospitals. Finally, the regression coefficients on the proportion of Hispanic and African-American patients in the hospital, and poverty in the region are large and significant. Recall that our estimates of feeding-tube use already control at the individual level for patient race and ethnicity, so these coefficients more likely reflect factors such as financial stress arising from high rates of Medicaid and uncompensated care patients served by these hospitals.

Table 3.4e – Relationship between Competition and Quality of End of Life Care for Dementia Patients (Feeding Tube Placement)

	Model 1 OLS	**Model 2** OLS	**Model 3** OLS	**Model 4** OLS	**Model 5** IV	**Model 6** IV
LOCI	5.461	7.698	4.393	4.893	6.159	2.115
	(5.44)	(7.57)	(4.58)	(4.26)	(5.05)	(1.78)
Fraction suburban	−4.598	−3.515	−1.979	−4.721	−4.082	−2.444
	(4.11)	(3.20)	(2.06)	(4.21)	(3.65)	(2.65)
Fraction large town	−1.361	0.731	0.021	−1.515	−0.266	−0.859
	(1.89)	(0.98)	(0.03)	(2.06)	(0.33)	(1.13)
Rural	−3.986	−1.509	−1.676	−4.066	−2.569	−2.425
	(4.54)	(1.66)	(1.96)	(4.62)	(2.66)	(2.59)
Log dementia volume		1.992	1.432		1.215	0.847
		(8.25)	(6.54)		(3.61)	(2.54)
Fraction Black			15.200			16.266
			(10.71)			(8.47)
Fraction Hispanic			12.435			12.869
			(7.35)			(8.48)
Fraction poverty			29.999			29.419
			(6.91)			(5.83)
Teaching hospital			−2.121			−1.729
			(4.97)			(4.44)
Not-for-profit hospital			−1.323			−1.374
			(3.68)			(3.30)
Government hospital			−1.492			−1.638
			(2.96)			(3.03)
Constant	4.061	−6.045	−5.258	4.457	−1.635	−1.282
	(5.49)	(4.25)	(3.82)	(5.34)	(0.83)	(0.66)

Discussion

Does competition in health care lead to better outcomes and lower costs? There is little agreement in this controversy, with papers finding positive, negative or zero associations. In this chapter, we revisit this question by deriving a model that expresses in a fixed-price regime the association between competition and quality. We estimated the model with a national sample of Medicare fee-for-service patients during 2010-11, aggregated up to the hospital level. Our primary focus was to test the standard model of competition as to whether diseases or procedures with either greater demand elasticity or higher profit margins exhibited greater effects of competition on quality. Generally, we found the answer to be no. While the use of high-value beta blockers following AMI was greater in more competitive regions, the association between competition and 30-day AMI mortality was sensitive to model specification. Hip and knee replacements, arguably the cleanest cohort with high theoretical elasticity of demand and a reputation for sizable financial margins, showed little consistent association between competition and quality. For dementia patients, which are likely to exhibit low elasticity of demand with respect to quality and zero or negative financial margins, poor clinical care was positively associated with competition—a result arguably consistent with the theoretical model when financial margins are negative.

Hospital care is far from a homogeneous product and the difficulty of observing quality is a well-known problem. We have attempted to include a broad array of available technical quality measures in our analyses, and have been able to include outcome measures of importance to patients, rather than solely process measures. There are publically available data for AMI mortality but not for complication rates after joint replacement or rate of feeding tube placement among advanced dementia patients. Under these circumstances, competition may mean recruiting the best physicians, reaching out to primary care doctors, or more traditional interpretations of market power. Hospitals may choose to invest in amenities rather than quality if they think the elasticity with respect to quality to be low. Indeed, in more complex models, Katz (2013) has suggested that in a fixed-price regime, greater competition may *reduce* the quality equilibrium in healthcare markets under certain circumstances.

One of the key questions is whether it's worthwhile for hospitals to compete on quality if neither patients nor referring physicians can distinguish between high—and low—quality hospitals, either because they do not have sufficient information, or because they simply don't pay attention? For example, it may be difficult for patients to observe technical hospital quality; quality measures may ignore commonly available objective measures such as hospital infection rates (Emanuel and Steinmetz, 2013), and quality measures for hip and knee replacements are often limited to just readmission rates (Chandra *et al*., 2016). Also, patients may not be familiar with public reports on quality (Schneider and Lieberman, 2001; Schneider and Epstein, 1998) and could choose a hospital based on distance or amenities (Goldman and Romley, 2008; Luft *et al*. 1990). Newer initiatives seek to inform consumers on public reporting of quality, and employer-sponsored, crowd-sourced, and mandated price reporting.[1] Research shows that use of these tools is low (Whaley *et al*., 2014; Desai *et al*., 2016), with a variety of explanations for their low use. Examples include (a) not knowing about their existence, (b) lack of health insurance literacy, (c) absence of consistency across different rankings, and (d) few incentives to choose a lower-cost provider.

A further complexity of the competition story arises from the intermediate role of physicians in directing patients toward or away from a particular hospital, as in preliminary work by Bynum *et al*. (2014). When choosing where to have one's knee replaced, for example, a patient may ask their primary care doctor for advice and a referral. Those physicians

1. For example, see *www.castlighthealth.com, www.clearhealthcosts.com, and https://nhhealthcost.nh.gov.*

may recommend based on the perceived quality of the hospital, but other evidence suggests that physicians are more likely to refer to their own affiliated hospital, even when it is low-quality (Baker *et al*., 2015).

Despite this concern that health care markets are uniquely inefficient, several recent studies provide evidence that patients do make their way to higher quality providers. Chandra *et al*. (2016) finds that higher-quality hospitals experience more rapid growth in volume of patients over time, with roughly one-quarter of the secular gain in AMI survival attributed to reallocation from lower to higher quality hospitals, with smaller effects for pneumonia and heart failure. Less clear is whether regions with higher concentration experience more rapid or slower reallocation of patients to higher-quality hospitals.[1] Similarly, Santos *et al*. (2016) have shown that in England, high-quality physicians (as measured by public ratings) are more likely to attract patients. Clearly, there must be some information about quality getting through to patients, although the mechanism is not always clear.

We acknowledge the limitations of this analysis. Previous studies have used changes over time in competition to study changes over time in quality of care (e.g., Kessler and McClellan, 2000), or plausible natural experiments in political alignment or health care reforms to predict competition (e.g., Gaynor *et al*., 2013; Cooper *et al*., 2011, 2013). Our cross-sectional analysis allows us to test longer-term equilibrium outcomes, but also risks biases arising from hospital fixed effects that are correlated with competition measures. We do not measure patient-reported quality measures, such as patient satisfaction, where arguably hospitals may find it most valuable to compete.[2]

1. They do find that transfer patients are more likely to seek out higher-quality hospitals; presumably these patients, who have been stabilized, are better able to choose from among the universe of nearby hospitals.
2. Although see Chandra *et al*., 2016, who find no evidence that patient satisfaction is associated with growth in patient volume.

We also recognize the limitations of Medicare fee-for-service claims data, which is only a fraction of the hospital's total market, and does not capture the hospital's Medicare managed care population. Additionally, in Europe, waiting times are an important component of quality—one that we do not account for in our theoretical model or empirical work. Finally, we have followed the conventional literature in measuring "competition" by whether one's neighbors seek care at many different hospitals, but these may or may not translate into the motivations and actions of hospitals in implementing quality improvement initiatives, nor do our measures reflect that in some areas, patients may be more skilled at searching than others.

What do our results mean for the current U.S. debate about competition *versus* coordination in health care? Regulators balance allowing mergers based on potential benefits from clinical integration while trying to promote price and quality competition in commercial markets and quality competition with fixed-price payers. Our paper (and others) suggests that consolidation *per se* is modestly associated with a decline in quality for cardiac care, but that clinical integration could also lead to higher volumes of patients treated at higher-quality, or at least higher-volume hospitals. Preliminary evidence is also beginning to emerge that under payment models incentivizing care coordination and accountability, formal financial integration is not necessary to achieve clinical integration. Therefore, potential effects of mergers on commercial prices could still be the most important consideration for regulators.

In sum, we did not find strong evidence in support of the standard models of competition on quality. This may mean that the information available to consumers is fragmented and incomplete, or that potential patients are not very skilled in looking outside of their local neighborhoods for higher quality facilities (Ho and Pakes, 2014), rather than an indictment of competition *per se*. Further validation of quality measures and consumer (or physician) knowledge about these measures would be of great value, and have implications for the consolidation currently accelerating under risk-based payment models.

Appendix – Mathematical Derivations

Derivation of equation (2): the derivation of cost if providers choose their level of quality to maximize profit and there are zero profits in equilibrium

$$\frac{d\pi_{tj}}{dz_j} = \overline{p}\frac{dx_i}{dz_j} - \frac{dC}{dx_j}\frac{dx_j}{dz_j} - \frac{dC}{dz_j} \tag{2a}$$

$$\frac{d\pi_{tj}}{dz_j} = \left(\overline{p} - MCx_j\right)\frac{dx_j}{dz_j} - \frac{dC}{dz_j} = 0 \tag{2b}$$

$$\left[\overline{p} - MCx_j\right]\frac{dx_j}{dz_j} = MCz_j \tag{2c}$$

Derivation of equation (4): the derivative of hospital *j*'s demand with respect to its own quality

$$\frac{d\widehat{x_j}}{dz_j} = \sum_{t=1}^{T} N_t \left[\frac{d}{dz_j}\frac{exp\left(\alpha z_j + a_{tj} + \epsilon_{tj}\right)}{\sum_{t'=1}^{T} exp\left(\alpha z_j + a_{t'j} + \epsilon_{t'j}\right)}\right]$$

$$= \sum_{t=1}^{T} N_t \left[\alpha\, exp\left(\alpha z_j + a_{tj} + \epsilon_{tj}\right)\left(\sum_{t'=1}^{T} exp\left(\alpha z_j + a_{t'j} + \epsilon_{t'j}\right)\right)^{-1}\right.$$

$$\left. + \alpha\, exp\left(\alpha z_j + a_{tj} + \epsilon_{tj}\right)^2 (-1)\left(\sum_{t'=1}^{T} exp\left(\alpha z_j + a_{t'j} + \epsilon_{t'j}\right)\right)^{-2}\right]$$

$$= \alpha \sum_{t=1}^{T} N_t \frac{exp\left(\alpha z_j + a_{tj} + \epsilon_{tj}\right)}{\sum_{t'=1}^{T} exp\left(\alpha z_j + a_{t'j} + \epsilon_{t'j}\right)}\left[1 - \frac{exp\left(\alpha z_j + a_{tj} + \epsilon_{tj}\right)}{\sum_{t'=1}^{T} exp\left(\alpha z_j + a_{t'j} + \epsilon_{t'j}\right)}\right]$$

$$= \alpha \sum_{t=1}^{T}\left(N_t \frac{exp\left(\alpha z_j + a_{tj} + \epsilon_{tj}\right)}{\sum_{t'=1}^{T} exp\left(\alpha z_j + a_{t'j} + \epsilon_{t'j}\right)}\right)\left(\frac{N_t}{N_t}\left[1 - \frac{exp\left(\alpha z_j + a_{tj} + \epsilon_{tj}\right)}{\sum_{t'=1}^{T} exp\left(\alpha z_j + a_{t'j} + \epsilon_{t'j}\right)}\right]\right)$$

$$= \alpha \sum_{t=1}^{T} (\hat{x}_{tj})\left(1 - \frac{\hat{x}_{tj}}{N_t}\right)$$

Thus

$$\frac{d\hat{x}_j}{\hat{x}_j dz_j} = \alpha \sum_{t=1}^{T} \frac{\hat{x}_{tj}}{\hat{x}_j}\left(1 - \frac{\hat{x}_{tj}}{N_t}\right) = \alpha \; LOCI_j$$

So the elasticity of demand with respect to a change in quality is equal to α times the LOCI measure.

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4

The Competition Effect of a French Reform on Hospital Quality

Laurent Gobillon and Carine Milcent[1]

Abstract

We study the effect on hospital quality of a pro-competition reform gradually introduced in France over the 2004-2008 period. Whereas before the reform public and non-profit hospitals were subject to a global budget system and private hospitals to a fee-for-service system, they are all subject to a Diagnostic Related Group (DRG) based payment system after the reform. We evaluate to what extent the incentives for hospital competition created by the reform affect mortality for the different types of hospitals using a difference-in-differences approach. Estimates are based on an exhaustive dataset of heart attack patients over the 1999-2011 period. We provide suggestive evidence that patients admitted in non-profit hospitals are less likely to die in less concentrated markets after the reform. For patients admitted in a public or a for-profit hospital, we do not find clear-cut results on the competition effect of the reform on mortality.

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INTRODUCTION

The market structure of the healthcare system is a major concern in most countries, as it has an impact on the quality of care as well as costs. Whereas healthcare has long been market-oriented in the US, several European countries—including the UK and France—have only recently changed to a market-oriented system from a non-market or strongly regulated market structure. These changes are part of a debate on the effect of reimbursement rules on hospital quality (Gaynor and Town, 2013).

In this chapter, we study the effect on hospital quality of a pro-competition reform gradually introduced in France over the 2004-2008 period. French hospitals can be in the private sector (for-profit) or in the public sector (non-profit or state-owned). Reimbursement rules differed in the two sectors before the reform. Whereas private hospitals were paid fees for services, non-profit and public hospitals were subject to a global budget system. The purpose of the reform was to homogenize the reimbursement rules for the two sectors into a Diagnostic Related Group (DRG) payment system. The transition was more consequential to the public sector and intended to encourage competitive behaviour. As prices are fixed in France, competition can only occur in quality. France is unique in that both public and private sectors provide a high level of quality.

Our study contributes to the growing empirical literature on competition and quality. This literature mostly evaluates the impact of local market concentration on heart attack mortality, which is considered to be a good indicator of quality.[1] Studies on the US provide empirical evidence based on cross-section variations in local competition. Results are mostly on Medicare patients and, although they are mixed, tilt somewhat toward lower

1. A recent exception is Colla *et al.* in this volume who study the effect of hospital competition not only for heart attack but also for hip and knee replacement, and dementia.

mortality in competitive markets. Kessler and McClellan (2000) and Kessler and Geppert (2005) find that local competition leads to lower mortality. Gowrisakaran and Town (2003) find the opposite for patients in California. In fact, the effect of competition on mortality is likely to depend on the reimbursement rate (Shen, 2003). If hospitals are underpaid for patients with a given insurance, such as Medicare, they have little or no incentive to compete for them by improving quality. In France, there is no selection of patients for whom hospitals compete based on insurance, since all patients are within the same insurance system.

There is also literature emerging in the UK which evaluates the effect of local competition on quality and which uses time variations in the intensity of local competition caused by a pro-competition reform introduced over the 2002-2006 period. This reform shares some elements with the one implemented in the public sector in France. Indeed, UK hospitals are public. The reform gave them some autonomy and changed the reimbursement system to a DRG payment system. It intensified local competition for patients in places where the healthcare structure was deconcentrated. Cooper *et al*. (2011) find that the reform led to a decrease in mortality trend in more competitive local markets. Gaynor *et al*. (2013) obtain similar results when studying mortality in level and additionally show that the reform saved lives without raising costs. In fact, most prominent scholars consider that the UK reform had positive effects on hospital quality (Bloom *et al*., 2011).

We evaluate the impact of the pro-competition French reform using an exhaustive dataset of in-hospital patients over the 1999-2011 period. We focus on patients aged 35 and over with an acute myocardial infarction (AMI). We consider separate specific effects for hospitals in the private sector and those in the public sector, and then distinguish non-profit, university and non-teaching hospitals in the public sector. We assess to what extent the intensification of local competition has a negative effect on mortality for the different types of hospitals using linear probability models for in-hospital mortality within 30 days. Additional regressions using a Cox duration model stratified by hospitals are provided in Gobillon and Milcent (2017).

In our main set of regressions, we use a measure of local competition centred on the hospital and defined as the average of Herfindahl-Hirschman Indices (HHI) computed for every patient taking into account establishments in a 30 km radius around her place of residence. We exploit the variations in market structure across hospitals and examine whether mortality decreases more for hospitals in less concentrated markets than for those in more concentrated markets after the reform. This is a difference-in-differences approach dealing with the fact that the reform applied to all hospitals in France. We then compare the difference-in-differences estimators obtained for hospitals in the private sector and those in the public sector as the effect of the pro-competition reform varies across hospital statuses, and this amount to making triple differences.

We provide suggestive evidence that patients admitted in non-profit hospitals are less likely to die in less concentrated markets after the reform. For patients admitted in a public or a for-profit hospital, we do not find clear-cut results on the competition effect of the reform on mortality.

The rest of the chapter is organized as follows. The next part gives some information on the French healthcare system as well as the pro-competition reform. It also gives details on our quality indicator and our main measure of local competition. Our empirical strategy is presented on page 172 and we comment the results on page 180. We provide robustness checks on page 184 and finally make some concluding remarks on page 191.

Context

French Healthcare System

The French Reform

We now propose a brief description drawn from Gobillon and Milcent (2017) of the French Health Care System, and explain how the reform changed the funding of hospitals and may have affected their behaviour. In France, the hospital healthcare system is publicly funded. There are three hospital ownership statuses: state-owned, non-profit and for-profit, which characteristics are described in Figure 4.1. Teaching and research activities are assigned to specific state-owned facilities that we label "university hospitals" (the usual label in French is *Centre hospitalo-universitaire* or *CHU*). They differ in their size and use of high-tech equipment when compared to other state-owned facilities, which we label "non-teaching public hospitals".

Individuals can choose rather freely the hospital where they receive care, although there is a minor restriction to the region of residence. In fact, over the 1998-2003 period, 93% of AMI patients were treated in their region of residence (Gobillon and Milcent, 2013). There is a unique public health insurance system which covers almost all in-patient expenditures of the whole population, whatever the ownership status of the hospital. A large part of the population also has additional private health insurance that covers mainly dental care, optical care, and an additional part of medications for outpatients.[1]

The reform of the hospital healthcare system took place over the 2004-2008 period. Prior to the reform, hospitals in the public sector (which includes state-owned facilities and non-profit facilities) were funded under a global budget system. They did not have any specific reason to attract patients, and they could choose whether or not to work cooperatively,

1. More details on the French healthcare system and differences across hospitals depending on their ownership can be found in Dormont and Milcent (in this volume).

<table>
<tr><td>Type</td><td>University hospital</td><td>Non-teaching public hospitals</td><td>Non-profit hospitals</td><td colspan="2">For-profit hospitals</td></tr>
<tr><td>Public status</td><td colspan="2">Yes</td><td colspan="3">No</td></tr>
<tr><td>Public sector</td><td colspan="3">Yes</td><td colspan="2">No</td></tr>
<tr><td>Ownership</td><td colspan="2">State-owned</td><td>Not-for-profit</td><td colspan="2">For-profit</td></tr>
<tr><td>Workers' status for non-doctors</td><td colspan="2">Civil servants and salaried workers</td><td colspan="3">Salaried workers</td></tr>
<tr><td>Workers' status for doctors</td><td colspan="2">Civil servants</td><td colspan="3">Salaried workers and private practice</td></tr>
<tr><td>Profit</td><td colspan="2">No profit
Surplus given to the state</td><td>Cannot make profit but surplus can be re-invested</td><td colspan="2">Can make profit</td></tr>
<tr><td colspan="6">Before reform</td></tr>
<tr><td>Funding</td><td colspan="3">Budget global</td><td>Fee-for-service</td><td>Per diem</td></tr>
<tr><td>Medical devices</td><td colspan="3">No additional budget</td><td colspan="2">Reimbursed per unit, tariff defined at the local level</td></tr>
<tr><td>Research activities</td><td>Additional budget[a]</td><td>No</td><td>No</td><td colspan="2">No</td></tr>
<tr><td colspan="6">After reform</td></tr>
<tr><td>Funding</td><td colspan="5">DRGs based payment</td></tr>
<tr><td>Medical devices</td><td colspan="5">If on a restricted list, reimbursed per unit, tariff determined at the national level
If not on the list, no additional payment</td></tr>
<tr><td>Research activities</td><td>Additional budget[a]</td><td>No</td><td>No</td><td colspan="2">No</td></tr>
</table>

a. Part of the additional budget for research activities may have been used for medical devices such as stents for AMI patients.

Figure 4.1 – Description of Hospital Ownership Statuses in France.

depending on their own will and the incentives from local health authorities. In March 2004, the reform labelled "Tarification à l'activité"—T2A was introduced, and a funding system based on Diagnostic Related Groups (DRG) was gradually implemented. The proportion of hospitals under this new funding system was 10% in 2004, 25% in 2005, 35% in 2006, 50% in 2007 and 100% in 2008. Currently, all hospitals in the public sector are given money for each stay depending on the DRG, which is determined by taking into account the degree of pathological severity. A fixed payment is associated to each DRG and the total amount of money received by a hospital depends on the volume of patients with each DRG and the associated payment.[1] As funding depends on the volume of patients, hospitals have incentives to compete for patients.

In the private sector, hospitals are funded for each stay. Prior to the T2A reform, hospitals received a fee-for-service payment, which amount depended on local health authorities and the procedures implemented during the stay. In March 2005, the fee-for-service funding system was replaced by a DRG system. The reform homogenized payments received by hospitals for patients with the same pathologies and procedures. As in the public sector, the DRG system created some incentives for hospitals to compete for patients. Nevertheless, this was already the case with the fee-for-services system. However, it is important to note that, as the DRG system is now also implemented in the public sector, private hospitals do not compete only among themselves after the reform, but also with public and non-profit hospitals.

The payment for every DRG is set every year by the government so that the overall funding of hospitals complies with national budget constraint. DRG payments take into account the average costs of stays and the volume

1. An additional budget is allocated to some hospitals because they provide specific public services such as teaching.

of care at the national level. They thus depend on global healthcare activity: the more important the activity, the lower the payments for DRGs.

The result of the reform is a unique payment system for both the public and private sectors. It is believed by national authorities that after the reform, all care providers have an incentive to attract patients and compete with others on quality, as prices are fixed. Nevertheless, it is unlikely that patients in France have some precise information on all hospitals. Indeed, hospital choice depends mostly on reputation, which is determined by information from relatives or social networks. After the reform, reputation is also influenced by some newspapers, which have decided to establish a ranking of hospitals by pathology, but the information remains vague. This means that incentives for competitive quality remain limited, because quality improvements in some hospitals could remain undetected. A website[1] provides information on hospitals but it is hard to interpret to get a quick idea of hospital quality and nothing is said on mortality. As a consequence, this website is poorly used by the population.

Overall, we anticipate that the effect of the reform should vary depending on hospital ownership. Regarding for-profit hospitals, the reform mostly increases the number of providers to compete with. For hospitals in the public sector (non-profit and State-owned), the reform both changes significantly the reimbursement rules of a payment per stay—which can have a direct effect on the quality of treatment—and induces competition with other providers. We therefore anticipate a stronger effect of the reform on the public sector than on the private one.

Ultimately, the pro-competition effect of the reform depends on the extent to which the market is locally de-concentrated and hospital quality is observable by patients. In this chapter, we assess whether hospitals in less concentrated local markets propose better healthcare quality to attract AMI patients after the reform, especially when they are in the public sector.

1. *http://www.scopesante.fr/.*

Comparison with Reforms in Other Countries

The French pro-competition reform combines some changes in reimbursement rules for two different sectors, which can be compared to reforms in other countries. The transition from a fee-for-service system to a DRG-related system for private hospitals is similar to the reform that was implemented in the US in the eighties. The transition from a global budget system to a DRG-related system for hospitals in the public sector shares some elements with the reform that was implemented in the UK over the 2002-2006 period.

In the UK, healthcare is provided by the National Health System (NHS) and is free whatever the use. Just before the reform, from 1997 to 2002, the health care clients (local governmental organisations) coordinated clinical-care packages and negotiated with health care providers (NHS-owned facilities) for annual contracts based on price, quality and volume. Patients were referred to the local hospital that was able to provide the service they required, and they could usually not choose their healthcare facility.

After gradual changes over the 2002-2006 period, the NHS encourages hospital competition for volume based on non-price aspects of services and care. This was achieved by changing reimbursement rules to a prospective payment system based on DRGs. Hospitals are paid for each admission and the price is fixed for each DRG, as in France with T2A.[1] Hospitals are given greater fiscal and managerial autonomy, and they can reinvest surpluses over fiscal years. This makes them comparable to French non-profit hospitals but more independent than state-owned French hospitals. Patients are allowed to choose where they receive care and the government has introduced a new information system providing quality information to patients. A government-run website gives some details on various aspects of establishment performances including: risk-adjusted mortality rates, hospital

1. There are some DRG adjustments, depending on pathology severity, local wage rates and whether hospitals are academic centres.

activity levels, waiting times and infection rates, all of which are sorted by procedures. Patients are much better informed than in France, where there is no real dissemination of information by the government.

Overall, whereas the French reform is likely to encourage competition, hospital incentives are probably not as strong as those introduced by the UK reform.

Quality Indicator

The most commonly used measure of hospital quality in the health economics literature is the mortality rate of AMI patients within 30 days after admission. This measure has been used in papers assessing how hospital competition affects hospital quality (Kessler and McClellan, 2000; Kessler and Geppert, 2005; Gowrisakaran and Town, 2003; Bloom *et al*., 2010; Cooper *et al*., 2011; Gaynor *et al*., 2013).

There are several reasons why this indicator is used extensively in studies on the UK and the US. First, the volume of AMI admissions is large enough and deaths frequent enough to obtain reliable statistical results. This is also true for France, where ischemic diseases are a major cause of mortality. Second, infrastructures for treating AMI patients are common to other hospital services, making AMI mortality a good general marker of hospital quality (Gaynor, 2007). Third, it is believed that AMI patients are usually taken to one of the hospitals closest to their place of residence, which means that there is very little room for selection bias when studying the effect on mortality of local factors, such as local competition (Gaynor *et al*., 2013).

We also chose to study the mortality of AMI patients for these reasons, especially as results can be compared with those obtained for the UK and the US. An additional motivation is that we have data at a more disaggregated level than most studies, since we have data at the patient level rather than at the hospital level. Moreover, our data are exhaustive for all stays of patients admitted in an acute care unit for a heart attack in France. We are able to study mortality at the individual level and we focus on in-hospital mortality at 30 days. Only deaths occurring within hospitals are taken into account as we cannot track patients when they are discharged. Our goal is to compare how mortality varies with local competition before and after the reform by hospital status.

There are some composition effects when studying mortality that can be taken into account with patient characteristics at the individual level. These characteristics include not only age and sex, but also secondary diagnoses and comorbidities. As information on secondary diagnoses and comorbidities is often not available, researchers prefer to use some indices such as the Charlson index. In our data, the detailed information on secondary diagnoses and comorbidities allows us to control for them in our regressions at the patient level. One may still argue that this information is not enough, but McClellan and Staiger (1999) show that when the main secondary diagnoses and comorbidities affecting mortality risk are considered, considerably more detailed medical data do not add much to capture heterogeneity among patients.

As Cooper *et al*. (2011) and Gaynor *et al*. (2013), we will also control for treatment with angioplasty, which is an innovative procedure used for AMI patient healthcare and which consists in inflating a balloon in a vein or artery to crush a blockage that caused the heart attack.

Our Indicator for Local Competition

A major challenge is to measure local competition with a proper index at the relevant geographic level. This issue is still debated in the literature with alternative proposals made by researchers. In this context, we will present results for a specific index already used by Cooper *et al*. (2011) and we will conduct extensive robustness checks using alternative indexes which results will be reported in a specific section.

Our main measure is an index of local concentration centred on the hospital and defined as the average of Herfindahl-Hirschman Indices (HHI) computed for every patient taking into account establishments in a 30 km radius around her place of residence.

More precisely, consider a given patient i and denote d_{ik} the distance between its place of residence and hospital k. The HHI for individual i is given by:

$$HHI_i = \sum_{k|d_{ik} \leq 30km} \left(\frac{N_k}{\bar{N}^i}\right)^2$$

where N_k is the number of AMI patients in hospital k and $\bar{N}^i = \sum_{k|d_{ik} \leq 30km} N_k$ is the total number of AMI patients within 30 km of the patient's place of residence.[1] This index measures hospital concentration around the patient. The lower the index, the more competition there is for the patient. The concentration measure at the hospital level is obtained by averaging the indexes of all patients within the hospital:

$$HHI^j = \frac{1}{N_j} \sum_{i \in j} HHI_i$$

The larger this measure, the less the hospital is in competition with other establishments for its patients.

EMPIRICAL STRATEGY

We now present the approach we use to evaluate the competition effect of the reform on quality. Our final goal is to test the hypothesis that the reform improves hospital quality through an increase in local competition. We present results according to hospital status as the effect of the reform is likely to depend on the reimbursement rules. For-profit

1. Denote by n^i the number of hospitals within 30 km of patient i. The HHI_i index varies from $1/n^i$ to 1 as the concentration of patients occurs within fewer hospitals. When $HHI_i = 1/n^i$, patients around individual i are equi-distributed between the n^i hospitals. When $HHI_i = 1$, they are all treated within one hospital.

hospitals compete for patients both before and after the reform, albeit they are under different funding regimes. By contrast, hospitals in the public sector had no incentive to compete for patients before the reform, but have some incentives to do so to get some funding after the reform. We first contrast hospitals in the private sector with those in the public sector, before distinguishing non-profit, university and non-teaching public hospitals in the public sector.

We exploit the variation in local market structure across hospitals as we examine whether quality improves more in hospitals in less concentrated markets than in hospitals in concentrated markets after the reform. This is akin to difference-in-differences approaches usually used to estimate the effects of policy reforms. Nevertheless, in our case, there is no perfect control group as there is no hospital left unaffected by the reform. Identification is rather secured by the existence of spatial variations in the level of local concentration of hospitals, as in papers studying the UK reform (Cooper *et al*., 2011; Gaynor *et al*., 2013). However, there is an additional twist in our study. We compare the difference-in-differences estimators obtained for hospitals in the private sector and those in the public sector as the effect of the pro-competition reform varies across hospital statuses, and this amount to making triple differences.

We begin our analysis by assessing the effect of the reform in the long run keeping only two dates, 1999 and 2011, and studying how mortality has evolved over the period in the same spirit as Gaynor *et al*. (2013). Our specification is a linear probability model given by:

$$\begin{aligned} m_{iht} = {} & b_0 + b_1 \mathrm{I}_{\{t=2011\}} + b_2 FP_h * \mathrm{I}_{\{t=2011\}} + b_3\ HHI_{h,t} + b_4 HHI_{h,t} * FP_h \\ & + b_5\ HHI_{h,t} * FP_h * \mathrm{I}_{\{t=2011\}} + b_6\ HHI_{h,t} * Pub_h * \mathrm{I}_{\{t=2011\}} \\ & + X_i b_7 + v_h + u_{iht} \end{aligned} \tag{1}$$

where m_{iht} is a dummy for mortality for patient *i* admitted in hospital *h* during year *t*, $HHI_{h,t}$ is the concentration index, FP_h is a dummy equal to one if the hospital is for-profit and zero otherwise, Pub_h is a dummy equal to one if the hospital is in the public sector and zero otherwise, $I_{\{t=2011\}}$ is a dummy for year 2011, X_i is a set of patient variables, v_h is a hospital fixed effect (included or not) and u_{iht} is random noise.

Our main coefficients of interest are b_5 and b_6 which measure the competition effect of the reform respectively for hospitals in the private sector and those in the public sector. Some other explanatory variables are used as controls. These include the concentration index, its interaction with a dummy for for-profit status as well as individual characteristics related to case-mix (interactions between sex and age brackets, detailed information on secondary diagnoses and comorbidities, average income in the municipality) and procedures (treatment with angioplasty). Endogeneity of the concentration index involved in several terms is a usual concern that arises because the hospital choice of patients itself can be endogenous (Bresnahan, 1989). Hospital fixed effects are used to take into account the unobserved hospital heterogeneity that may affect the hospital choice of patients and thus may be correlated with the concentration index. We also provide additional robustness checks in a specific section in which we resort to a concentration index constructed from predicted flows of patients in line with Kessler and McClellan (2000).

We also assess to what extent hospitals in the public sector are affected by the competition effect of the reform on mortality depending on whether they are non-profit, university or non-teaching. For that purpose, we re-estimate the specification by hospital status. By contrasting results for non-profit and state-owned hospitals, we capture the impact of managerial autonomy. Also, comparing results obtained for university and non-teaching hospitals makes it possible to isolate the impact of having teaching activities.[1]

1. Note that teaching hospitals are on average larger than non-teaching public ones and the difference in size and activity is also captured when comparing the two types of hospitals.

As a complement, we conduct estimations on all years over the 1999-2011 period to use all the information available in the data and estimate both the short-run and long-run competition effects of the reform. As the reform occurred in 2005 for for-profit hospitals, the post-reform period is considered to be from 2005 onwards. As the reform occurred gradually between 2004 and 2008 for hospitals in the public sector, we distinguish for them two periods: the transition over the 2004-2007 period and the period when the reform is fully implemented from 2008 onwards. More precisely, the specification is given by:

$$\begin{aligned} q_{iht} = {} & \beta_0 + \beta_1 t + \beta_2 \mathrm{I}_{\{t \geq 2004\}} * Pub_h + \beta_3 \mathrm{I}_{\{t \geq 2008\}} * Pub_h \\ & + \beta_4 \mathrm{I}_{\{t \geq 2005\}} * FP_h \\ & + \beta_5 HHI_{h,t} + \beta_6 t * HHI_{h,t} + \beta_7 HHI_{h,t} * FP_h \\ & + \beta_8 HHI_{h,t} * FP_h * \mathrm{I}_{\{t \geq 2005\}} \\ & + \beta_9 HHI_{h,t} * Pub_h * \mathrm{I}_{\{t \geq 2004\}} + \beta_{10} HHI_{h,t} * Pub_h * \mathrm{I}_{\{t \geq 2008\}} \\ & + X_i \beta_{11} + u_{iht} \end{aligned} \tag{2}$$

where $\mathrm{I}_{\{.\}}$ is the indicator function and t is the time trend.

Our main coefficients of interest are β_8 which captures for for-profit hospitals the average competition effect of the reform from 2005 onwards, as well as β_9 and β_{10} which capture for hospitals in the public sector respectively the average competition effect of the reform since its start in 2004 and the additional effect once the reform is complete in 2008. For hospitals in the public sector, whereas the competition effect of the reform is β_9 over the 2004-2007 period, it becomes $\beta_9 + \beta_{10}$ from 2008 onwards.

As previously, other explanatory variables are used as controls. These include a time trend, a dummy for for-profit status, dummies capturing period effects interacted with dummies for hospital statuses, a concentration index, an interaction between the time trend and the concentration index, an interaction between the concentration index and the dummy for for-profit status, as well as the same individual variables as in specification (1) capturing effects related to case-mix and treatment with an angioplasty. We also conduct separate regressions by hospital status to identify the effect of managerial autonomy and the effect of having teaching activities.

Data and Preliminary Statistics

Data

We use the exhaustive data on stays in French hospitals provided by the *Programme de médicalisation des systèmes d'information* over the 1999-2011 period as detailed in Gobillon and Milcent (2017). We restrict our attention to patients admitted to a hospital for an AMI. Because heart attacks before age 35 are usually related to a heart dysfunction, we consider only patients aged 35 and over, which is in line with the OMS definition. Stays with duration coded zero (4.6% of observations) are excluded.

The resulting sample includes 870,549 stays for mainland France with an average of 66,965 stays per year.[1] Hospital admissions occur for patients coming from home stays (80.5%), from another hospital (18.9%), or from another service of the same hospital (0.6%).

As we cannot keep track of patients when they are transferred to another hospital or service, we restrict our sample to patients who come from their place of residence. We thus discard 19.5% of observations, which makes the sample size drop to 704,509 stays with an average of 54,193 stays per year.

We have information on patients' age and sex, as well as detailed information on co-morbidities (i.e. pre-existing conditions), secondary diagnoses and treatment procedures. Detailed co-morbidities and diagnoses are related to the way of life (smoking, alcoholism, obesity, hypertension), chronic health problems (diabetes, conduction diseases, history of

1. We exclude from the analysis patients and hospitals from Dom-Tom and Corsica, as well as patients from foreign countries, as healthcare is very specific in that case.

coronary disease), disease complications (renal failure, heart failure), and site of heart attack (anterior, posterior, sub-endocardial, other). We know whether patients were treated or not with an angioplasty.

We also have the municipality code of residence and we use it to recover the municipality household median income in 2000 from fiscal data. This measure is used as a proxy for patients' social background that may influence their probability of death since we do not have any information on it in our main dataset.

Finally, our concentration index is computed on the whole sample of patients in mainland France. We have the municipality codes for both the patients' place of residence and the location of hospitals.[1] We match these codes with an additional dataset containing the coordinates of the town hall and compute the distance between patients and hospitals as crow flies using these coordinates.

We delete 4.12% of observations for which information is missing or miscoded, and end up with 675,469 stays with an average of 51,959 stays per year, with 20.4% of stays being in for-profit hospitals, 3.4% in non-profit hospitals, and 76.2% in public hospital (of those, 27.6% are in university hospitals and 48.6% in non-teaching public hospitals). We also know the type of discharge: death (7.2%), home return (61.0%), transfer to another service (2.0%) or transfer to another hospital (29.8%). As we cannot follow patients when they are discharged, we study patients during their stay within the hospital. We focus on discharge due to death and treat all other discharges as right censored.

1. There are around 36,000 municipalities in mainland France. There are two large groups of establishments, one in Paris (called *Assistance publique-Hôpitaux de Paris*) and the other one in Marseille (called *Assistance publique-Hôpitaux de Marseille*), for which we do not have a specific municipality code for each establishment. We therefore attribute them the municipality code of the first district in their respective city.

Preliminary Statistics

We first assess whether the distribution of patients across hospital statuses changes over the 1999-2011 period, especially after the implementation of the reform. Figure 4.2 shows that this distribution does not vary much over time. There are only slight changes in demographic characteristics. Whereas the proportion of male patients declines from 70% to 68%, the proportion of patients more than 85 years old increases from 8.2% to 9.2% for females and from 4.5% to 5.8% for males.

There is some heterogeneity in patients' composition across hospital statuses as shown by Table A.1 (p. 194). In particular, the proportion of patients aged 35-55 is about 22% in university hospitals but only 15.5% in non-teaching public hospitals. The length of stay is 7.9 days in non-teaching public hospitals but only 7.0 days in for-profit hospitals.

The mortality rate is around 7% over the period but once again, there is some heterogeneity across hospital statuses since it is as high as 8.6% in non-teaching public hospitals but only 5% in for-profit hospitals, 5.7% in university hospitals, and 7.8% in non-profit hospitals. Figure 4.3 shows that the mortality rate decreases over the whole period, especially after the beginning of the reform in 2004 with the trend becoming steeper. Table A.2 (p. 195) shows that the mortality rate decreases over time whatever the hospital status. This decrease can be explained by an increase over time in the use of innovative technologies (in particular, angioplasty and stent) for every hospital status.

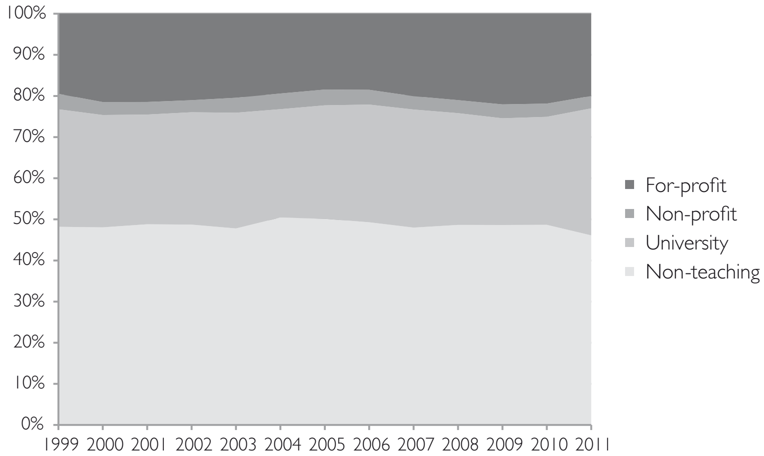

Figure 4.2 – Distribution of Patients across Hospital Statuses over the 1999-2011 Period.

Note: for a given year, each color represents a status and the height the percentage of patients in hospital of such status. Percentages sum to 100%.

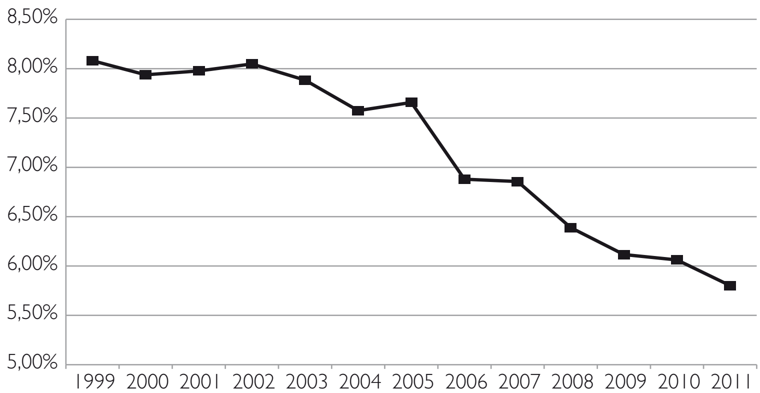

Figure 4.3 – Mortality Rate over the 1999-2011 Period.

Results

Table 4.1 – Competition Effect of the Reform on Mortality between 1999 and 2011, Ordinary Least Squares

Estimated coefficient	All hospitals	For-profit hospitals	Hospitals in the public sector			
			All	Non-profit	University	Non-teaching
Year 2011	−0.0243***	−0.0277***	−0.0242***	−0.0629***	−0.0125**	−0.0296***
	(0.00327)	(0.00643)	(0.00378)	(0.0168)	(0.00540)	(0.00558)
HHI	−0.00139	−0.0267***	0.000414	−0.0370	0.0141**	−0.00726
	(0.00417)	(0.00935)	(0.00466)	(0.0283)	(0.00714)	(0.00638)
Private sector	0.00660					
	(0.00408)					
HHI * Private sector	−0.0161***					
	(0.00554)					
HHI * Private sector	0.000414	0.00231				
* Year 2011	(0.00884)	(0.0127)				
HHI * Public sector	−0.000343		−0.000169	0.104**	−0.0135	0.00441
* Year 2011	(0.00567)		(0.00635)	(0.0459)	(0.00978)	(0.00874)
Patient characteristics	Yes	Yes	Yes	Yes	Yes	Yes
N	102,034	20,099	80,453	3,235	30,591	46,627
R^2	0.120	0.120	0.120	0.120	0.109	0.124

Notes: *significant at 10% level; ** significant at 5% level; *** significant at 1% level. Dependent variable: dummy taking the value one if the patient died at the hospital within 30 days after her admission following an AMI. Patient characteristics include: interaction between gender and age brackets, comorbidities, diagnoses, treatment with angioplasty, average income in the municipality. HHI: hospital weighted average of Herfindahl-Hirschman indexes computed for every patient taking into account establishments in a 30 km radius around her place of residence.

We now comment the results on the competition effect of the reform on mortality. We first focus on long-run effects by estimating specification (1) after restricting the sample to the years 1999 and 2011. As a first step, we ignore hospital unobserved heterogeneity and report in Table 4.1

the main coefficients of interest obtained with Ordinary Least Squares.[1] Results for the full sample in column (1) show that the reform would have a competition effect neither on hospitals in the private sector nor on those in the public sector. This is confirmed by columns (2) and (3) which give estimated coefficients when the specification is estimated separately for the two types of hospitals. We then dig further by re-estimating the model for the public sector by hospital status. Whereas the reform has a significant positive competition effect for non-profit hospitals (column 4), is has no significant competition effect for university and non-teaching public hospitals (columns 5 and 6). Hence, the introduction of the T2A reform would create competition incentives that are strong enough to decrease the mortality in non-profit hospitals only. This suggests that managerial autonomy would matter.

We then assess whether results remain the same when taking into account hospital unobserved heterogeneity. Table 4.2 gives the results when the specification is estimated in the within-hospital dimension. Results remain qualitatively similar although the estimated competition effect for non-profit hospitals is significant at the 5.2% level only (but this is very close to the 5% threshold).

To get an idea of the order of magnitude for the effects, we assess to what extent the change in mortality rate after the reform differs between low-competition and high-competition markets. A one standard deviation decrease in the concentration index (equal to 0.275) yields a decrease in mortality rate in non-profit hospitals according to the point estimate of 0.275*0.101*100 = 2.78 points between 1999 and 2011.[2] Corresponding figures for for-profit hospitals, university hospitals and non-teaching public hospitals are much smaller (in absolute terms) and amount to respectively

1. For other coefficients, similar results are commented in Gobillon and Milcent (2013) and Gobillon and Milcent (2016).
2. This corresponds to a yearly decrease in mortality rate of 2.78/13=0.214 points. This is a sizable effect but at the same time it is very imprecisely estimated.

–0.19 points, –0.18 points and –0.11 points. These estimated effects are not significant.

Table 4.2. Competition Effect of the Reform on Mortality between 1999 and 2011, Within Estimation

Estimated coefficient	All hospitals	For-profit hospitals	Hospitals in the public sector			
			All	Non-profit	University	Non-teaching
Year 2011	−0.0208***	−0.0239***	−0.0195***	−0.0239***	−0.0580***	−0.0145***
	(0.00350)	(0.00691)	(0.00401)	(0.00691)	(0.0184)	(0.00548)
HHI	−0.00248	−0.0124	−0.00212	−0.0124	−0.0462	−0.00173
	(0.00589)	(0.0113)	(0.00619)	(0.0113)	(0.0399)	(0.00931)
HHI * Private sector	−0.00786					
	(0.0122)					
HHI * Private sector	−0.00835	−0.00676				
* Year 2011	(0.00996)	(0.0137)				
HHI * Public sector	−0.00395		−0.00398	0.101*	−0.00653	-0.00395
* Year 2011	(0.00608)		(0.00679)	(0.0519)	(0.0100)	(0.00959)
Patient characteristics	Yes	Yes	Yes	Yes	Yes	Yes
N	102,034	20,099	80,453	3,235	30,591	46,627
R^2 Within	0.138	0.166	0.133	0.175	0.112	0.140

Notes: *significant at 10% level; ** significant at 5% level; *** significant at 1% level. Dependent variable: dummy taking the value one if the patient died at the hospital within 30 days after her admission following an AMI. Patient characteristics include: interaction between gender and age brackets, comorbidities, diagnoses, treatment with angioplasty, average income in the municipality. HHI: hospital weighted average of Herfindahl-Hirschman indexes computed for every patient taking into account establishments in a 30 km radius around her place of residence. R^2 Within gives the R^2 of the model projected in the Within dimension.

We then turn to results obtained using all the years of data over the 1999-2011 period. Results obtained with Ordinary Least Squares are reported in Table 4.3. When we pool all patients together (column 1), we find that the reform has no competition effect for for-profit hospitals, but has one during the 2004-2007 transition period for hospitals in the public

Table 4.3. Competition Effect of the Reform on Mortality over the 1999-2011 Period, Ordinary Least Squares

Estimated coefficient	All hospitals	For-profit hospitals	Hospitals in the public sector			
			All	Non-profit	University	Non-teaching
Time trend	−0.00173***	−0.00243***	−0.000767	−0.00238	0.000505	−0.00161
	(0.000421)	(0.000846)	(0.000728)	(0.00304)	(0.00104)	(0.00105)
Public sector *	−0.0139***		−0.0229***	−0.0321***	−0.0231***	−0.0266***
(Year ≥ 2004)	(0.00166)		(0.00218)	(0.00869)	(0.00334)	(0.00348)
Public sector *	−0.00630***		−0.00653***	−0.0317***	−0.00714*	−0.00289
(Year ≥ 2008)	(0.00144)		(0.00240)	(0.00932)	(0.00387)	(0.00381)
Private sector *	−0.00466***	− 0.0121***				
(Year ≥ 2005)	(0.00127)	(0.00302)				
HHI	−0.00295*	−0.0180***	−0.00444**	−0.0588***	−0.0202***	−0.0127***
	(0.00175)	(0.00355)	(0.00204)	(0.0134)	(0.00410)	(0.00295)
HHI * Time trend	0.00158	0.00178	0.00104	0.00660	− 0.00120	0.00225
	(0.00106)	(0.00179)	(0.00127)	(0.00793)	(0.00192)	(0.00174)
Private sector	−0.00297*					
	(0.00158)					
HHI * Private sector	−0.0154***					
	(0.00222)					
HHI * Public sector *	0.00507**		0.00670**	0.0271	−0.000872	0.00990**
(Year ≥ 2004)	(0.00235)		(0.00291)	(0.0185)	(0.00446)	(0.00396)
HHI * Public sector *	−0.00382*		−0.00214	0.0529***	−0.00557	−0.00275
(Year ≥ 2008)	(0.00231)		(0.00307)	(0.0200)	(0.00503)	(0.00407)
HHI * Private sector *	0.00158	0.00566				
(Year ≥ 2005)	(0.00106)	(0.00474)				
Patient characteristics	Yes	Yes	Yes	Yes	Yes	Yes
N	651,453	135,023	516,430	20,825	184,835	310,770
R^2	0.123	0.115	0.124	0.121	0.122	0.124

Notes: * significant at 10% level; ** significant at 5% level; *** significant at 1% level. Dependent variable: dummy taking the value one if the patient died at the hospital within 30 days after her admission following an AMI. (Year ≥ *t*): dummy for year greater or equal to *t*. Patient characteristics include: interaction between gender and age brackets, comorbidities, diagnoses, treatment with angioplasty, average income in the municipality. HHI: hospital weighted average of Herfindahl-Hirschman indexes computed for every patient taking into account establishments in a 30 km radius around her place of residence.

sector and this effect attenuates afterwards. These results are confirmed when the sample is stratified by hospital status and as previously there is some heterogeneity in the competition effect within the public sector. As before, there is a long-run effect of the reform for non-profit hospitals (column 4). Unlike previously, there is a positive effect of the reform on non-teaching public hospitals but it slightly attenuates over time (column 6).

Robustness Checks

We conduct extensive robustness checks changing the definition of our measure of concentration.

Alternative Measures of Concentration

We considered as our main measure of concentration, the average of patients' HHI centred on their place of residence that takes into account only hospitals within 30 km. However, there is no real consensus in the literature on which measure is the most relevant, and ultimately trust in the results depends on robustness checks made by varying the local measure of concentration and on how much people believe in the indexes that are used.

In particular, it is not clear which radius should be used when computing the HHI, as some patients may consider only very local options to remain close to home while others may consider longer distances to get admitted in high-tech hospitals. As a consequence we experimented with the alternative radiuses of 10, 20 and 50 km. A statistical determination of the relevant radius can also be considered, and we experimented with the 95th percentile of the distance between patients and hospitals computed by year. This radius is very large and its average across patients reaches 107 km.

In fact, it may not be the distances between patients and hospitals which are relevant. It may rather be whether patients and hospitals are located or not in the same city as the city could be the most relevant local healthcare market. Therefore, we also experimented with hospital concentration indexes computed at the urban area level and at the local labour market level. For instance, the index at the urban area level is computed as the sum of the squared ratio between the number of AMI patients in each hospital and the total number of AMI patients within the urban area.

Endogeneity is a concern when regressing a mortality variable on a concentration index constructed from patients' HHI because this index may be correlated with unobserved patient characteristics which effects are captured by the residual (see for instance Bresnahan, 1989; Kessler and McClellan, 2000). Indeed, patients are free to choose their hospital in France, and usually do so based on the information given by their physician, the press (a ranking of hospitals being published every year), family and relatives. It is possible that patients most likely to die are admitted to the best hospitals. These hospitals are mostly located in large cities where there is a considerable supply of good surgeons, and large cities usually exhibit a low concentration of hospitals. In that case, there is a negative correlation between the HHI index and the residual in specifications (1) and (2). On the other hand, good hospitals may be those that dominate locally and run the competition out of the market. Hospital quality could then be higher in more concentrated local markets, and we would then expect a positive correlation between the HHI index and the residual of our specifications. In line with the literature, we deal with unobservable patient characteristics by constructing an alternative HHI index from predicted flows of patients to hospitals. We first estimate a logit model of hospital choice, where the explanatory variables are the distance from patient to hospital, as well as interactions between age bracket × gender dummies at the patient level and dummies for hospital statuses. From these estimates, we deduce the probability of each patient going to each hospital, and thus predict the number of patients in each municipality going to each hospital. We then construct for patients of a given municipality a new set of patients' HHI indexes using predicted numbers of patients in the municipality going to every hospital on the territory. Our alternative concentration index for a given hospital is then a weighted average of these HHI computed across all patients, where the weight for a given patient is her probability of going to the hospital.

We also consider a competition index proposed by Antwi, Gaynor and Vogt (2013) instead of a concentration index.[1] This index called Logit Concentration Index (LOCI) is initially derived from a model of price competition. However, Colla *et al*. in this volume show that the LOCI also intervenes in a fixed price setting since they establish that the proportional responsiveness of admissions to an improvement of quality depends multiplicatively on the elasticity of demand with respect to quality and the LOCI that captures the competition mechanisms affecting demand. A detailed presentation of the LOCI index is proposed in Colla *et al*. in this volume and Appendix A. We compute the LOCI index for a given hospital taking into account only other hospitals within a 30 km radius consistently with our construction of the HHI index. We thus depart from Colla *et al*. in this volume who rather use hospital referral regions that cover the whole US. Note that the LOCI index varies in the way opposite to HHI indexes so that negative correlations with our concentration indexes are expected.

Results of Robustness Checks

We first assess to what extent our alternative indexes are related. Table 4.4 reports the correlations between all our indexes. All correlations have the expected sign. Every two concentrations indexes are positively correlated, and every concentration index is negatively correlated with the LOCI index. Except for a few exceptions, correlations are rather large ranging in absolute terms from 0.3 to 0.8.

We then check whether our results are robust when using these alternative indexes. Table 4.5 reports results obtained for specification (1)

1. Note that alternative indexes are possible such as the local number of hospitals (see Combes and Gobillon, 2015).

when the model is estimated with Ordinary Least Squares. The negative effect of competition on mortality is robust for non-profit hospitals. The estimated coefficient is even significant at 1% when using the urban area or the local labor market as the relevant healthcare market. The order of magnitude is similar to the one obtained using our main measure of concentration except when the maximum radius of the market for the alternative measure is the 95th percentile of distance. In that case, the geographic area defining the market is very large and very different from the one considered in other measures.

Table 4.4 – Correlations between Different Measures of Market Structure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	Mean	Standard deviation
(1)	1.000									0.612	0.259
(2)	0.747	1.000								0.584	0.325
(3)	−0.505	−0.484	1.000							0.477	0.201
(4)	0.232	0.349	−0.262	1.000						0.094	0.042
(5)	0.564	0.640	−0.370	0.307	1.000					0.686	0.294
(6)	0.559	0.711	−0.401	0.389	0.777	1.000				0.619	0.307
(7)	0.515	0.654	−0.422	0.458	0.630	0.800	1.000			0.499	0.280
(8)	0.399	0.545	−0.404	0.609	0.480	0.600	0.692	1.000		0.287	0.170
(9)	0.079	0.283	−0.302	0.482	0.234	0.338	0.383	0.489	1.000	0.139	0.077

Notes: correlations between nine alternative indexes of concentration or competition. All correlations are significant at the 0.1% threshold. HHI: Herfindhal-Hirschman Index; LOCI: LOgit Competition Index. (1) HHI at the employment area level; (2) HHI at the urban area level; (3) LOCI using a 30 km radius; (4) HHI using the 95th centile radius; (5) HHI using a 10 km radius; (6) HHI using a 20 km radius; (7) HHI using a 30 km radius (our main measure); (8) HHI using a 50 km radius; (9) HHI using a 30 km radius and applying Kessler and McClellan construction procedure.

Table 4.5 – Competition Effect of the Reform on Mortality between 1999 and 2011, Estimations with OLS when Using Alternative Measures of Competition

		For-profit	Non-profit	Univer-Sity	Non teaching		For-profit	Non-profit	Univer-sity	Non teaching
Index * Private *	(1)	−0.00532				(2)	−0.00437			
Year 2011		(0.0168)					(0.0139)			
Index * Public *			0.146***	−0.0333**	0.00924			0.109***	−0.0263**	0.0166**
Year 2011			(0.0430)	(0.0130)	(0.00952)			(0.0410)	(0.0105)	(0.00756)
Index * Private *	(3)	−0.0224				(4)	−0.0748			
Year 2011		(0.0206)					(0.0816)			
Index * Public *			−0.0514	0.0290	−0.0189			0.211	−0.0416	0.0898
Year 2011			(0.0667)	(0.0218)	(0.0153)			(0.284)	(0.0663)	(0.0701)
Index * Private *	(5)	0.0242*				(6)	0.00579			
Year 2011		(0.0134)					(0.0116)			
Index * Public *			0.0824**	0.0100	0.00583			0.0700*	−0.00856	0.0148*
Year 2011			(0.0359)	(0.0123)	(0.0115)			(0.0359)	(0.00939)	(0.00882)
Index * Private *	(7)	−0.00285				(8)	−0.0189			
Year 2011		(0.0216)					(0.0336)			
Index * Public *			0.117	−0.0295**	0.00190			0.098	−0.113***	0.0122**
Year 2011			(0.0814)	(0.0148)	(0.0144)			(0.122)	(0.0258)	(0.00623)

Notes: estimations conducted using eight alternatives indexes of concentration or competition. HHI: Herfindhal-Hirschman Index; LOCI: LOgit Competition Index. (1) HHI at the employment area level; (2) HHI at the urban area level; (3) LOCI using a 30 km radius; (4) HHI using the 95^{e} centile radius; (5) HHI using a 10 km radius; (6) HHI using a 20 km radius; (7) HHI using a 50 km radius; (8) HHI using a 30 km radius and applying Kessler and McClellan construction procedure.

We conduct the same exercise when hospital unobserved heterogeneity is taken into account by estimating the model in the Within dimension. Results reported in Table 4.6 for non-profit hospitals are in line with those in Table 4.5. For non-teaching public hospitals, the competition effect of the reform is never significant. A bit surprisingly, in case the concentration index is measured at the local labor market level, we find a positive competition effect of the reform on mortality for for-profit and university hospitals that would suggest that an increase in local competition would increase mortality. This could be explained by the existence of other types of hospitals capturing part of their market share. However, confidence in the results relies ultimately in the trust that it is really competition that the concentration index captures. Note that we also find a positive competition effect of the reform on mortality for university hospitals when using the Kessler and McClellan index.

Table 4.6 – Competition Effect of the Reform on Mortality between 1999 and 2011, Within Estimations when Using Alternative Measures of Competition

		For-profit	Non-profit	University	Non teaching		For-profit	Non-profit	University	Non teaching
Index * Private * Year 2011	(1)	−0.0512** (0.0210)				(2)	−0.0257 (0.0175)			
Index * Public * Year 2011			0.111** (0.0544)	−0.0417*** (0.0136)	0.00389 (0.0111)			0.130*** (0.0499)	−0.0182 (0.0111)	0.00909 (0.00886)
Index * Private * Year 2011	(3)	0.0149 (0.0276)				(4)	−0.0696 (0.0920)			
Index * Public * Year 2011			−0.242** (0.0984)	0.0182 (0.0260)	−0.0191 (0.0197)			0.182 (0.343)	0.0262 (0.0688)	0.0297 (0.0799)
Index * Private * Year 2011	(5)	0.0180 (0.0142)				(6)	−0.00647 (0.0124)			
Index * Public * Year 2011			0.0459 (0.0394)	0.0178 (0.0125)	0.00365 (0.0128)			0.0410 (0.0399)	−0.000112 (0.00958)	0.00385 (0.00972)
Index * Private * Year 2011	(7)	−0.0213 (0.0239)				(8)	−0.0338 (0.0401)			
Index * Public * Year 2011			0.154 (0.160)	−0.0119 (0.0155)	0.00906 (0.0159)			0.170* (0.0897)	−0.105*** (0.0268)	0.0116 (0.0602)

Notes: estimations conducted using eight alternatives indexes of concentration or competition. HHI: Herfindhal-Hirschman Index; LOCI: LOgit Competition Index. (1) HHI at the employment area level; (2) HHI at the urban area level; (3) LOCI using a 30 km radius; (4) HHI using the 95th centile radius; (5) HHI using a 10 km radius; (6) HHI using a 20 km radius; (7) HHI using a 50 km radius; (8) HHI using a 30 km radius and applying Kessler and McClellan construction procedure.

Table 4.7 – Competition Effect of the Reform on Mortality over the 1999-2011 Period, Estimations with OLS when Using Alternative Measures of Competition

		For-profit	Non-profit	University	Non teaching		For-profit	Non-profit	University	Non teaching
Index * Public *	(1)		0.0362**	0.0243***	0.0199***	(2)		0.0157	−0.00297	0.0149***
(Year ≥ 2004)			(0.0181)	(0.00601)	(0.00445)			(0.0158)	(0.00488)	(0.00347)
Index * Public *			0.0523**	−0.00441	−0.00888*			0.0606***	−0.0125**	−0.00251
(Year ≥ 2008)			(0.0208)	(0.00686)	(0.00481)			(0.0172)	(0.00577)	(0.00359)
Index * Private *		−0.00187					−0.000823			
(Year ≥ 2005)		(0.00616)					(0.00504)			
Index * Public *	(3)		−0.0656***	−0.00457	-0.0106	(4)		0.0185	0.0301	-0.0395
(Year ≥ 2004)			(0.0206)	(0.00805)	(0.00755)			(0.0157)	(0.0305)	(0.0312)
Index * Public *			−0.00150	0.0213**	−0.00912			0.0462***	−0.0210	−0.000563
(Year ≥ 2008)			(0.0279)	(0.00923)	(0.00687)			(0.0159)	(0.0277)	(0.0276)
Index * Private *		−0.00508					−0.0469*			
(Year ≥ 2005)		(0.00846)					(0.0279)			
Index * Public *	(5)		0.0200	0.0157***	0.0194***	(6)		−0.0355	0.00392	0.0171***
(Year ≥ 2004)			(0.0148)	(0.00520)	(0.00517)			(0.0377)	(0.00421)	(0.00394)
Index * Public *			0.0322**	−0.00479	−0.0110**			0.105***	−0.00599	−0.00598
(Year ≥ 2008)			(0.0158)	(0.00575)	(0.00545)			(0.0346)	(0.00473)	(0.00412)
Index * Private *		0.00773					0.00554			
(Year ≥ 2005)		(0.00483)					(0.00424)			
Index * Public *	(7)		−0.0355	−0.00737	0.00327	(8)		0.0241	0.102	0.00137
(Year ≥ 2004)			(0.0377)	(0.00729)	(0.00686)			(0.0152)	(0.0845)	(0.0245)
Index * Public *			0.105***	−0.0124	0.00253			0.0538***	−0.0236	0.0237
(Year ≥ 2008)			(0.0346)	(0.00761)	(0.00636)			(0.0173)	(0.0887)	(0.0253)
Index * Private *		−0.00368					−0.0482***			
(Year ≥ 2005)		(0.00802)					(0.0147)			

Notes: estimations conducted using eight alternatives indexes of concentration or competition. HHI: Herfindhal-Hirschman Index; LOCI: Logit Competition Index. (1) HHI at the employment area level; (2) HHI at the urban area level; (3) LOCI using a-30 km radius; (4) HHI using the 95th centile radius; (5) HHI using a 10 km radius; (6) HHI using a 20 km radius; (7) HHI using a 50 km radius; (8) HHI using a 30 km radius and applying Kessler and McClellan construction procedure.

We repeat the same exercise for the evaluation of the competition effect of the reform on the whole 1999-2011 period. Results of robustness checks when the model is estimated with OLS are reported in Table 4.7. Overall, they are rather in line with those in Table 4.4 for non-profit hospitals although the magnitude of the estimated coefficients during the 2004-2007 transition period and afterwards varies across specifications.

Conclusion

The emerging evidence in the literature examining competition in a fixed-priced market is the positive correlation between competition and hospital quality. Results in the US are obtained for hospitals that are privately-run providers. Those for the UK concern the effect of a reform such that public hospitals have been given a more important managerial and fiscal autonomy. In France, there are three different hospital ownership statuses and the specific effect of competition on quality can be assessed by status within the same country.

In this chapter, we study the effect on hospital quality of a pro-competition reform gradually introduced in France over the 2004-2008 period. Whereas public and non-profit hospitals are under a global budget system and private hospitals are under a fee-for-service system before the reform, they are all under a diagnostic-related-group (DRG) payment system after the reform. We evaluate to what extent incentives for hospital competition created by the reform affect quality for the different types of hospitals. Estimations are conducted on an exhaustive dataset of heart attack patients over the 1999-2011 period for whom the 30-day in-hospital mortality is studied.

Our results suggest that patients admitted in non-profit hospitals are less likely to die in less concentrated markets after the reform. Nevertheless, it would not be the case for those in for-profit and public hospitals. This suggests that the funding system and management rules matter for the effect of the reform.

In our analysis, we use several alternative measures of local concentration to assess the robustness of our results. There is still no consensus on which index is the most relevant in particular because the way patients choose their hospital is still imperfectly known and is likely to vary across countries depending on institutions. This issue deserves additional empirical work.

We have considered that hospital quality is captured by the survival rate within the hospital. However, there are other dimensions to quality such as the room, the medicine devoted to every patient, or the attention paid by the staff to the well-being of patients. Moreover, we limited our attention to patients having a heart attack as the mortality rate for this pathology is considered to be a good predictor of hospital quality. However, the competition effect of the reform could well vary across pathologies depending on whether it is profitable or not to better cure patients after the reform. These topics are left for future research.

Appendix A. Details on the Logit Concentration index

We now give information on the Logit Concentration Index (LOCI) following Antwi, Gaynor and Vogt (2013) and Colla *et al*. in this volume.

The LOCI index for a given hospital captures the fractions of patients in municipalities which are not admitted in the hospital. It therefore corresponds to the potential market of the hospital. The LOCI is given by the formula:

$$\Lambda_j = \sum_{m \in \Phi_j} \frac{N_m S_{m \to j}}{\sum_{m \in \Phi_j} N_m S_{m \to j}} \left(1 - S_{m \to j}\right)$$

where m indexes the municipality, Φ_j is the set of municipalities from which the hospital draws patients, $S_{m \to j}$ is the share of patients in municipality m admitted in hospital j and N_m is the number of patients in municipality m.

The LOCI takes the value zero when the hospital has admitted every patient living in municipalities from which it draws patients. The LOCI tends to one when the market is perfectly competitive. It is important to note that the HHI and LOCI differ in their treatment of large and small hospitals. Consider a geographic area consisting in two municipalities such that there is a large hospital in a municipality and a small one in the other municipality. Suppose that each hospital draws the same proportional number of patients from each municipality. The HHI is identical for the two municipalities and so is then the HHI of the two hospitals, as a hospital HHI is computed as the weighted average of municipality HHIs (where the weight is the hospital share of patients coming from the municipality). By contrast, the LOCI is higher for the small hospital because the fraction of patients in each municipality not admitted in that hospital is larger. This index better captures the idea that there would be a larger potential market for the small hospital and thus more incentives for competition.

Table A.1. Summary Statistics by Hospital Status

Variable	All hospitals		University hospitals		Non-teaching public hospitals		Non-profit hospitals		For-profit hospitals	
	Mean (%)	Standard deviation	Mean (%)	Standard deviation	Mean (%)	Standard deviation	Mean (%)	Standard deviation	Mean (%)	Standard deviation
Female, 55-65	3.00	0.171	3.31	0.179	2.80	0.165	2.97	0.170	3.05	0.172
Female, 65-75	6.24	0.242	6.02	0.238	6.36	0.244	6.23	0.242	6.27	0.242
Female, 75-85	11.43	0.318	9.59	0.294	12.98	0.336	12.63	0.332	10.30	0.304
Female, more than 85	8.93	0.285	6.80	0.252	11.55	0.320	10.21	0.303	5.71	0.232
Male,35-55	18.12	0.385	21.94	0.414	15.58	0.363	16.99	0.376	18.72	0.390
Male,55-65	15.13	0.358	17.12	0.377	13.00	0.336	14.94	0.357	17.26	0.378
Male,65-75	15.37	0.361	15.42	0.361	14.45	0.352	14.98	0.357	17.51	0.380
Male,75-85	13.90	0.346	12.40	0.330	14.65	0.354	13.37	0.340	14.39	0.351
Male, more than 85	4.96	0.217	3.88	0.193	6.02	0.238	5.05	0.219	4.03	0.197
Alcoohol problems	1.30	0.114	1.33	0.115	1.43	0.119	0.99	0.099	1.04	0.101
Smoking problems	13.95	0.346	18.07	0.385	11.97	0.325	9.81	0.298	13.48	0.342
Obesity	8.28	0.276	10.33	0.304	7.17	0.258	7.78	0.268	8.09	0.273
Diabetes	17.45	0.380	16.66	0.373	17.64	0.381	19.00	0.392	17.86	0.383
Hypertension	35.64	0.479	35.27	0.478	34.82	0.476	39.89	0.490	37.37	0.484
Renal failure	6.92	0.254	6.99	0.255	7.38	0.261	8.11	0.273	5.58	0.230
Valvular disease	5.45	0.227	4.38	0.205	5.00	0.218	6.14	0.240	7.83	0.269
Peripheral arterial disease	6.21	0.241	5.91	0.236	5.89	0.236	8.63	0.281	6.96	0.255
Other vascular disease	3.33	0.179	3.04	0.172	3.47	0.183	3.33	0.180	3.39	0.181
Other ischemic disease	4.61	0.210	3.76	0.190	4.07	0.198	5.36	0.225	6.91	0.254
Heart failure	16.69	0.373	14.32	0.350	19.14	0.393	19.59	0.397	13.82	0.345
Conduction disease	21.02	0.408	17.86	0.383	22.49	0.418	23.30	0.423	21.64	0.412
Stent	43.65	0.496	57.38	0.495	27.52	0.447	48.47	0.500	60.54	0.489
Length Of Stay	7.574	7.091	7.493	7.660	7.873	7.164	7.6953	7.112	6.978	5.936

Notes: descriptive statistics computed on the sample of patients aged 35-100 admitted from their place of residence (and not a transfer).

Table A.2. Thirty-day Patient Mortality over the 1999-2011 Period (in %), by Hospital Status

	All hospitals			University hospitals		Non-teaching public hospitals		Non-profit hospitals		For-profit hospitals	
	Nb. Obs.	Mean (%)	Std Dev.	Mean (%)	Std Dev.	Mean (%)	Std Dev.	Mean (%)	Std Dev.	Mean (%)	Std Dev.
1999	50,975	7.95	0.2705	6.55	0.2474	9.51	0.2933	8.34	0.2765	6.23	0.2418
2000	53,277	7.79	0.2681	6.50	0.2465	9.40	0.2918	7.95	0.2706	5.99	0.2373
2001	54,841	7.82	0.2684	6.37	0.2443	9.51	0.2933	9.29	0.2903	5.71	0.2321
2002	54,585	7.88	0.2695	6.68	0.2497	9.69	0.2958	9.17	0.2888	5.28	0.2237
2003	54,309	7.77	0.2677	6.29	0.2428	9.47	0.2929	9.59	0.2945	5.68	0.2315
2004	51,906	7.42	0.2621	5.95	0.2365	9.16	0.2884	7.33	0.2607	5.13	0.2205
2005	49,530	7.44	0.2624	6.13	0.2399	9.09	0.2875	7.42	0.2622	5.07	0.2193
2006	48,372	6.69	0.2498	5.05	0.2189	8.35	0.2766	8.03	0.2718	4.71	0.2119
2007	48,808	6.71	0.2503	5.43	0.2265	8.17	0.2739	7.79	0.2681	5.02	0.2184
2008	49,208	6.17	0.2405	4.74	0.2124	7.63	0.2655	7.03	0.2558	4.87	0.2153
2009	50,359	5.86	0.2349	4.72	0.2121	7.15	0.2577	6.64	0.2491	4.63	0.2102
2010	51,377	5.79	0.2335	4.66	0.2109	7.21	0.2587	6.03	0.2381	4.33	0.2035
2011	51,063	5.68	0.2314	4.92	0.2164	6.94	0.2542	5.99	0.2374	3.95	0.1947
1999-2011	668,610	7.02	0.2554	5.68	0.2315	8.60	0.2804	7.76	0.2676	5.15	0.2209

Notes: descriptive statistics computed on the sample of patients aged 35-100 admitted from their place of residence (and not a transfer).

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Comments

Pedro Pita Barros and Jon Magnussen

Introduction

The chapters of this volume address issues of hospital competition and share the feature of addressing quality competition under fixed (prospective) prices.

From a theory point of view, the chapters take the final stage of a more complete game, in which prices are determined by regulation in an earlier stage and quality decisions follow. For empirical work, it is necessary to condition decisions on the prices and pricing rules of previous stages (unspecified in the chapters). It requires that quality be observable to the crucial decision maker.

A first point of clarification is whether the crucial decision maker for hospital competition in quality is the patient or the physician. Certain dimensions of quality may be observed by the patient, such as amenities and single vs. double room during admission, although that may tell little about clinical quality. On the other hand, physicians may focus too much on quality and forget about details that make the patient journey less problematic (being treated by the first name instead of being known by the room number, for example). The exact dimensions of quality that are subject to competition between hospitals may or may not be easier to change than regulated prices. The implicit larger sequential game requires, for consistency, that quality is changed more often than regulated prices. This may, or may not, be the case, according to the procedures that set the regulated prices and the dimensions of quality considered. Quality associated with the design of the hospital is certainly less easy to change than regulated prices.

We organized the discussion on a paper-by-paper basis, starting with the (selective) review of the theoretical literature, and then moving to the empirical papers.

Hospital Quality Competition: Review of the Theoretical Literature

The main question addressed in this volume can be stated broadly as the impact of hospital competition on quality. In the chapter presented by Brekke *et al*. the answer is provided by a comparative statics exercise on a stylized model.

A different, complementary, question of interest is about the optimal quality levels: does competition bring too much, too little, or about the right quality? This also is of policy relevance as it immediately raises the issue of whether policy makers should go for more or less competition between hospitals in quality.

Above, we asked for a clearer definition of quality, to define the conditions for application of the results of the papers. But it is required to have a definition of what is "more competition". In the work by Brekke et al., there are several different ways throughout the paper to define what is meant by "more competition". To review the main ones: more competition is identified with smaller "transport" costs, holding number of competitors constant; with more competitors, holding "transport" costs constant; with different solution concepts-closed loop vs. open loop solution (knowledge about rivals); and, with a smaller proportion of patients in a monopolistic segment (not explored as such, but can be interpreted in this way).

A small note to add, transport costs are interpreted as a proxy for comparative information on quality. We are not totally convinced by this interpretation and would prefer to see the full model, instead of some loose argument. Perhaps some models of product awareness may be a useful guide for development of such a more general model.

This review chapter assumes away price competition for most of it and looks at the impact of competition on quality of care under different assumptions regarding 1) the degree of altruism of providers; 2) the existence of profit constraints or soft budget constraints; 3) alternative cost structures; 4) the degree of differentiation (or degree of specialization); and 5) sluggish demand adjustments.

Some common features are easily identified. Competition affects the elasticity of demand to quality intensity and the level of demand. Competition changes the level of demand, either at the provider level or at the market level-demand diversion vs. demand creation effects.

There are assumptions not discussed that deserve, in our view, some attention. Prices are assumed to be prospective prices, and not just being fixed). If alternatively there is some degree of cost sharing, it reduces the cost, supply-side, effects and gives more weight to demand-side effects in the impact of competition. We find it unlikely to alter the main results.

The review provides an answer to the question of what conditions need to be met for competition to have a positive impact on quality. The theoretical conditions reported and treated are simple: whatever increases demand sensitiveness and has marginal cost of treatment decreasing in quality. Thus, increasing competition between hospitals under fixed (prospective) prices does not always result in higher quality. The general result is of ambiguity, but direction of different forces is identified.

The initial section of the paper highlights the direct effects, working through demand functions and cost functions. It ignores all effects resulting from quality choice of rivals. It is more about demand shifters than about competition. It helps to understand effects down the road, when strategic interaction is introduced.

The gains from increasing quality include one, the other, or both of the following: higher demand (either diverted or created), and lower marginal cost of treating a patient, which affects the interest in having more demand (margin effect). The effects can be classified into demand-side effects—how responsive is demand to quality; what is the change in the level of demand—and on supply-side effects—how quality influences costs (marginal costs of treating patients).

After the first set-up, the review goes into specialization, defined as different treatment endogenously determined, not just as a shifter of demand. The well-known forces for differentiation in spatial models are present, and more competition leads hospitals to differentiate as a way to reduce competitive pressures.

The authors have a section devoted to sluggish demand, that is, demand that adjusts over time. We are not really sure about the interest of this section in this particular review of the effects of competition on quality under fixed prices. It is qualitatively different—the analytical focus is on the transition to equilibrium—and it needs providers of care to have very flexible quality decisions. There is no detailed discussion of the reason why patients react differently. The degree of competition is identified with the solution concept applied. It is debatable whether this is a relevant concept of competition. Leaving this last issue open, the section distracts the reader from the main framework underlying the other sections in the paper.

Soft budget constraints are a major issue in countries with public hospitals funded by general taxation. The soft budget constraint aspect is treated as probability of bail out in case of losses (which is nice way of doing it). The existence of soft budget constraints reduces the costs of quality choice in the low demand state to provider. Consequently, it increases the incentive for quality. Two extensions come quickly to mind. First, higher quality may influence which state of demand occurs at the provider level. Second, the probability of bail out may well depend on how large the provider is. In a "too large to fail" case, there is a further incentive to invest in quality (too much?), as it increases the probability of bail out. If total demand is constant and determined by the characteristics of the population, then having all providers investing more in quality does not change the distribution of patients across them but has higher costs. Whether this is good or bad depends on what the socially optimal level of quality is. Related to this comment, moral hazard on efficiency deserves more than a footnote, as it may reverse some of the results.

The role of information asymmetries, uncertainty, adverse selection and moral hazard are ignored. These features, often part of the problems in health care markets, deserve a comment on whether they are relevant or not for the implications of competition between hospitals on quality; whether, or not, competition in quality between hospitals under asymmetric information is technically (more) difficult to treat; whether or not there is an impact of these aspects on the major results.

A couple of other general features were sidestepped, deserving future attention in research. When discussing competition in quality, in systems based on a Government-run National Health Service, the role of competition between public and private hospitals becomes relevant. Not only as a matter of (possibly) different objectives of each type of hospital. The public hospital and its objectives may be itself an instrument of intervention in the hospital market, as it may act as a Stackelberg leader and the way patients have (possible) copayments structured influences the market equilibrium (see Barros and Martinez-Giralt, 2002, on this). Different modes of payment may lead to asymmetric equilibrium (e.g., if not paying for hospital outside of the network of third-party payer, it creates an advantage for the in-network provider, reflected on prices paid by patients; arguably this may be of lesser importance in health systems where in which hospitals predominate.)

Quality is assumed to be product specific throughout the review. A more general treatment can look at provider-wide, across products, quality features. This brings in the role of economies of scope, which add complexity and one more effect. Our conjecture is that ambiguity will result with (dis)economies of scope in favour of (negative) positive effect of competition on quality.

A final word is needed about price competition and how it may affect the results reviewed in this paper. The claim produced by the authors, "with endogenous prices, the requirements for competition to increase quality are more stringent than with fixed prices", is based on the margin effect and lower prices under price competition. But it can be less simple than it seems, depending on the way prices are set and how price competition unfolds. Price competition under reimbursement insurance will soften competition, and bargaining with payers may be tougher. This is another area to explore: the effect of modes of price competition on later stages of quality competition under fixed (prospective) prices (at the stage of quality choices).

In terms of welfare analysis, the authors look at optimal price regulation. Optimal price regulation gives price as instrument to the regulator, so no surprise on result is found. But price is also a guide to quality, and in settings where fixed prices result from some type of negotiation between insurers and hospitals, the signaling aspect of prices may play some role and more importantly optimal price regulation cannot be assumed. More challenging is the situation in which prices are endogenous and the regulator can influence only rules of payment and/or objective function of provider.

To briefly summarize the main results highlighted by this review chapter: Lower "transport" costs have a positive effect on the impact of competition on quality; less sluggish demand has a positive effect (under open loop); marginal cost of treatment decreasing with quality has a positive effect on quality; and altruism—if it reaches a production decision with negative margins—implies a negative effect of competition on quality (overall profits will include a payment transfer).

After a review on the theoretical aspects of more competition on quality, the natural next question is "what evidence do we have?" This is taken up in the next sections, in which empirical papers presented are discussed.

Ownership and Hospital Productivity

This chapter, by Brigitte Dormont and Carine Milcent, addresses the issue of differential productivity across hospitals with distinct ownership. The starting point is that crude productivity measures indicate that in France public and private nonprofit hospitals are more costly than private hospitals. The analysis carried out in this paper shows that the productivity gap is due to the mandate of public hospitals: they cannot specialize and cannot turn down patients. Non-profit hospitals are subject to the same rules of public hospitals. Put in a different way, it explores the question of differences in patients explaining productivity differences.

Another relevant aspect is the implication of cost structures for payment rules. Adoption of prospective payments in France assumes no scale or scope economies. The underlying assumption is that size and composition of activity are not relevant. A fair question to ask is whether or not this is true.

While these are natural questions, a third element should be considered, quality of management. The private French hospital sector has large chains of private hospitals. It covers 1/3 of discharges. There are several difficulties in measuring real costs and profitability. For example, cost definition does not include doctor's payment in the private sector, but does so in the public sector. Direct cost comparisons have to control for such differences.

Given the problems with cost definitions, the analysis concentrates on production. Hospitals are multiproduct entities, dealing with many productions. To accommodate this feature in a tractable way, there is a synthetic scale. According to this scale, public hospitals are less productive than not-for-profit hospitals, which are less productive than private hospitals. The authors estimate a production function, taking six production factors: physicians, nurses, assistant personnel, administrative personnel, beds as a proxy for fixed equipment, and support staff. The main result is that adjusting for the mix of patients and their characteristics, public hospitals are more efficient, providing a reverse in the ranking once patient characteristics are explicitly accounted for.

On technical grounds, productive efficiency depends on the production frontier specification. With a classic production function, public hospitals are worse, but not after accounting for patients' characteristics. Lower productivity in public hospitals is explained by oversized establishments, patient characteristics, production characteristics, but not by inefficiency in short to medium term management. Of course, size is a management decision but taken at a higher hierarchical level.

Three points are left for future discussion. First, whether or not there are differences due to emergency departments. Second, whether or not teaching and training plays a minor role. Third, whether or not the health professions' mix is the same in the public and private sides.

The paper challenges current views on two grounds: first, superiority of private management based on crude indicators, and, second the use of uniform regulated prices under the presence of economies of scale (and scope) and the mandate to serve all demand that appears at the regulated price. The use of a production function approach does not allow for discussing input price advantages that one sector may have over the other (public vs. private). Extending the analysis to input-prices effects is a natural next step.

Hospital Competition, Quality, and Expenditures in the US Medicare Population

This chapter seeks to measure the impact of competition on quality. From the theory review, another issue of interest immediately arises: the impact of competition on demand sensitivity. In addition to these demand-side effects, the empirical analysis should ideally address the supply-side aspect: what are the marginal cost effects (which mediate the impact of competition on quality)?

These questions set a broader empirical agenda than the one that can be tackled within this particular chapter. Another possible title, more in line with the implications that can be drawn, is "Should we encourage quality competition among hospitals?".

From the theoretical review, a lesson learned is the ambiguity of results. More competition is not always better for increasing quality. The empirical results seem to support this ambiguity. As stated by the authors, in a somewhat benevolent view with regard to the role of competition, the paper "Finds (at best) modest support for the standard competition model".

The empirical analysis assumes, pretty much in line with the theory review, that prices are fixed. Prices have to be fixed at some stage. The reader needs to know more about this stage and whether the level of competition in quality is also influenced by that stage. For example, from the theory review, we know that prices/margins affect incentives for quality, and that altruism may lead to negative margins, which reverses the incentives for more quality if more competition is introduced.

Unlike the theory review, this paper makes the assumption of free entry in addition to fixed prices, meaning that entrants have to take existing prices. This assumption begs evidence of this entry (and that entrants take previous prices as given). The setting is clearly tailored to the United States health system. Free entry does not characterize many (most) of the health systems in Europe. In particular, whenever public provision of care through a National Health Service is present, entry is subject to system planning and political decisions, not to market forces. Some entry of private hospitals does exist but it cannot be claimed to be a general characterization of conditions under which quality competition unfolds in the health system.

One important point from theory was the role of demand diversion and demand creation effects, and providing more information about these effects in the clinical procedures selected for exploration is welcome. From a birds-eye view, it seems unlikely to have demand creation for AMI, perhaps some may be present for dementia, and more so for hip and knee replacement. This should be put to closer scrutiny and discussion.

Cost structures played an important role in the theoretical model, and nothing is said or tested about them in the present paper. It may be worthwhile to know how quality affects the cost of treatment in each of the procedures and across hospitals, even if coming from other empirical works on the United States hospital market.

On the empirical procedure, competition levels across markets are the key issue, and the competition level is measured by summary indices. The paper deliberately avoids estimation of a structural model, focusing instead on reduced form equations and a competition index to trace the effects of more (or less) competition. The standard index is the HHI concentration index, which requires a careful definition of market boundaries and which rivals are included in the market.

The authors note, correctly, that the HHI may not be the best one for differentiated products. The theoretical underpinnings of the HHI index are based on homogeneous oligopoly competition, in which this measure of market concentration can be directly linked to the difference in prices to marginal costs as a measure of exercise of market power. No such theoretical link can be claimed for the case of differentiated products and the HHI. Thus, the authors suggest using the LOCI index proposed in Akosa-Antwi, Gaynor and Vogt (2006).

This index, used to measure competition in markets with differentiated products, has a theoretical background. It also has a problem: it was constructed for price competition. It is a structural measure but has a behavior assumption included in its derivation—competition comes from more firms dividing the same market (and this was the least interesting form of competition in the theoretical model of quality competition between hospitals). Thus, an important challenge results: can we make a better "bridge" from theory to a summary indicator of quality, and not price, competition?

The effort to have a theory-based index is important. Two features suggest that an index different from LOCI should be used. The first feature is the assumption of free entry, which is not present in the computation of the LOCI, based on the first-order condition for profit maximization.

The second feature is that LOCI is derived based on price competition while the empirical setting takes prices as fixed (citing from the text, "In this paper, we tested the standard model of competition subject to fixed prices in the US medicare market").

The approach used to derive the LOCI can be easily adapted to a setup of quality competition under fixed prices. There are $j = 1,\ldots,J$ hospitals, $t = 1,\ldots,T$ different types of patients with N_t patients of each type. Types include patients with the same demand. The profit function is:

$$\Pi_j = \bar{p}_j D_j(\bar{\mathbf{p}},\mathbf{q}) - C_j\left(D_j(\bar{\mathbf{p}},\mathbf{q}), q_j\right)$$

Both the vector of (fixed) prices and the vector of (observable) qualities determine the demand for hospital treatment. Costs are a function of quantity of care (patients treated) and quality of care. We assume here a flexible representation, allowing quality of care to also affect the marginal cost of treating patients.

The corresponding first-order condition for profit maximization can be written as :

$$p_j = \frac{\partial C_j}{\partial D_j} + \frac{\partial C_j / \partial q_j}{\partial D_j / \partial q_j}$$

Taking the individual random utility model to be:

$$U_{tj} = -\alpha_1 \bar{p}_j + \alpha_2 q_j + a_{tj} + \varepsilon_{tj}$$

The last component, the error term, follows a Weibull distribution (generating a standard logit demand system, with quality as a decision variable instead of price). Total demand directed at a particular hospital is defined as:

$$D_j = \sum_{t=1}^{T} N_t \bar{m}_t \Pr(t \rightarrow j)$$

where $\bar{m}_t$ is the average quantity used by patients of type t. From this structure,

$$\frac{\partial \Pr}{\partial q_j} = \alpha_2 \Pr(t \to j)(1 - \Pr(t \to j))$$

Then,

$$p_j = \frac{\partial C_j}{\partial D_j} + \frac{1}{\alpha_2} \frac{\partial C_j / \partial q_j}{\sum_t N_t \bar{m}_t \Pr(t \to j)(1 - \Pr(t \to j))}$$

The LOCI in the original proposal of Akosa-Antwi *et al*. (2006) was defined as the additional term to marginal cost, which corresponds here to the second term in the right-hand-side excluding the scale factor α_2. Unlike the original LOCI, the second term depends on the marginal cost of quality, which concerns both the impact of quality on marginal costs of treating patients and on fixed costs (independent of treating patients, including here the costs of building quality).

The LOCI is based on market shares and the deviation to marginal cost pricing will include a term related to marginal cost of quality that is not reflected in the LOCI. This deviation is also different from the HHI index. Thus, we cannot state which of them, HHI or LOCI, is the more adequate summary index to include in the empirical analysis. For constant marginal cost of quality, it will be the LOCI, but it does demand this assumption. The authors opt to have a second-order Taylor approximation to derive a closed form expression for the quality level.

On the empirical procedures, there is a very careful analysis and definition of quality measures used for the clinical procedures selected. We would welcome information on the profit of each procedure per hospital (back to the price issue, or margin more precisely).

The "instrument" (in the econometric sense) is the number of hospitals. This option is a natural one, given the information available to the authors. However, it is still pretty much the same information set that is used in the competition index. In terms of theoretical consistency and under the initial assumption of free entry/exit, the number of hospitals should be endogenous to the degree of competition (which is not measured only by the number of competitors, as detailed in the theory review paper).

The obvious issue is then what other alternatives are possible. Since the interest lies in the role of competition, a possibility is to address reaction functions directly, using residual demand function estimation (an approach employed for prices in competition policy).

Another possibility is to explore information in other aspects known to have impact on the link between competition and quality. For example, explore the ability to have more on the role of non-profit/for-profit and soft budgets for some hospitals (e.g. explore differences in soft/hard budget constraints between non-profit part of larger organizations willing to take losses in hospital care *versus* profit-oriented hospitals). In a similar spirit, payment system differences can be used as a source of variation (not much is said in this paper about price formation and price variation across hospitals).

The arguments on demand being more or less sensitive to quality with more competition seems to call for interaction effects, and addressing both level of demand and sensitivity of demand could be potentially interesting, again drawing upon the results of the theory review paper.

A relevance test to the paper is given by asking the following question: do we understand enough of competition in quality to advise for more/less competition? The answer is "not yet", but this paper starts to walk the path leading to the answer.

Aspects that should be addressed in future empirical work include the definition and computation of better instruments and alternative to concentration indices; and the analysis of the welfare effects of quality at the margin (one always assumes that we have under-provision of quality, an assumption that should be subject to empirical testing).

These empirical results may also raise challenges to the economic theory. For example, is it possible to get the "right" level of quality in a decentralized way? What are the implications of taking competition as the reverse side of the coin to freedom of choice, taken as a value itself? There is also a need to know more about how quality competition takes place, about the relationship between sensitiveness of demand and patient information, about the relationship between more hospitals and the level of demand (determined by patients' decisions or by physicians' decisions?), about the impact of having more choice options to patients (with same number of hospitals), as (potential) benefits of more competition being weighted against investment duplication.

These points look at the desirability of having more competition to having more quality. A different, complementary, view is also required. Given an objective on quality, what's the best instrument to achieve it? In particular, knowing and assessing in a comparative view the alternative instruments to competition should help us understand when and why fostering competition is the right policy to follow.

On a quick take, three potential alternatives to increase quality are clinical protocols, pay for performance, and motivation of health professionals. Under clinical protocols as instrument for quality, the main issue is to define quality and monitor the process and outcomes that achieve it.

Under pay for performance, the point is to define observable quality measures and condition payment on their achievement.

A final general point refers to an assumption used in the discussion of the theory background of this paper, free entry and exit of providers, in what we may call the political economy of competition. This is not much of an issue in the United States, but countries with public hospitals inserted into a National Health Service, have to deal with how health bureaucracies deal with both entry and exit. Although most of the time the concern is with financial failure of hospitals and soft budget constraints, entry can be distorted as well. From the public side, it is possible to have too much entry due to "empire building" by hospital managers or by the bureaucracy that manages them. From the private side, it is possible to have too much entry due to the so-called "business stealing effect" in the presence of important fixed costs (as is the case with the construction of a new hospital)—the new hospital neglects the fact that part (most?) of its demand will come from other existing hospitals, and its private profitability of investment will be greater than the social profitability. On the exit, there is a large asymmetry between private and public hospitals. While the former will just go bankrupt and exit (where exit can mean to be acquired by another entity), the latter may benefit from soft budget constraints and absence of political will to close capacity. On exit, competition should force less efficient/lower quality hospitals to close activity, but soft budget constraints may exist and public hospitals remain open despite making permanent losses. Application of this empirical framework to countries with a National Health Service will have to recognize this feature.

The Competition Effect of a French Reform on Hospital Quality

Utilising a payment reform in France, Gobillon and Milcent discuss the relationship between market concentration, competition and quality. Their analysis is a welcome addition to a literature on hospital competition in which there are few empirical studies from a European setting.

Quality, even within the traditional structure-process-outcome framework of Donabedian, is a concept that is inherently multidimensional. Gobillon and Milcent choose, as is often done in these types of analysis, to limit their analysis to patients with acute myocardial infarction (AMI). The argument for this is as follows: first, patients with AMI will generally be admitted to the closest available hospital, thus there will be no selection bias for this patient group. Second, hospitals providing high quality care for patients with AMI are also likely to provide high quality care for all other patient types; hence quality for AMI patients is a valid indicator for overall hospital quality of care. Third, the quality of care for AMI patients can be adequately measured by 30 days in-hospital mortality rates.

The authors should not be criticised for choosing indicators of quality that are well-established in the literature. Studies from the NHS also seem to corroborate that when AMI mortality decreases following increased competition, so does mortality from other causes. Still, the notion that AMI is a general marker for hospital quality deserves to be discussed more thoroughly. One might propose that strategies followed by hospitals to increase quality "across the board" include following established protocols (process quality) and possibly also increasing costs. Obviously, there is room here for studies that apply a broader spectrum of quality measures.

In recent years we have seen pro-competitive reforms in several European countries. The simple rationale behind these reforms is that competition will increase both efficiency and quality, and—by extension—consumer welfare. Policy measures target demand side (extending patient choice and publication of performance (and quality) indicators), as well as supply side (payment reforms and the transformation of public hospitals into trusts) issues. The introduction of patient classification systems such as the DRG-system has also facilitated models in which prices can be administratively set, thus providing a setting in which hospitals may compete on quality rather than price.

To encourage competition regulators need to make sure that there is a well-functioning market for hospital services. Thus they need to be concerned about both the supply side (there need to be a sufficient number of hospitals actually competing for patients within a defined geographical area) and the demand side (there needs to be sufficient information available for patients or their referring physicians to make informed decisions about where to be treated).

The payment-reform that motivates the paper by Gobillon and Milcent largely concentrates on the supply side. One of their premises is that absence of market concentration is a necessary, but not a sufficient condition for competition. If hospitals are not financially penalised when they deliver low quality, either in the form of lower market shares or in the form of lower income, they are not likely to adapt to a competitive environment. Thus, the way hospitals are reimbursed will also have consequences for their behaviour. Gobillon and Milcent analyse the effects of the French payment reform in an environment where there are three distinct types of hospitals; private for-profit, private non-profit, and public state-owned. This provides a potential to analyse behavioural differences between different organizational forms, but also to study the effects of transition from a fee-for-service to a DRG-based system, vs the transition from a global budget to a DRG-based system.

In their analysis Gobillon and Milcent use a Herfindahl market concentration index as a proxy for degree of competition. Market concentration will obviously depend on the geographical area that is defined as a "market", and they present a number of alternative concentration measures. With some exceptions their results are robust to choice of measure. On the other hand the correlations between their different indices are often in the range of 0.4 to 0.6 and the practical interpretation of a change in HHIs is not clear. This has implications for policy decisions that affect market structure. Policy makers will want to know whether there is a lower threshold at which which markets can be said to be too concentrated as well as whether there is an upper threshold where the positive effects of competition are exhausted. When measures of concentration are diverse and poorly correlated the interpretation and corresponding policy implications of a possible association between "market structure" and quality becomes more difficult.

For strong believers in the merits of competition the results in Gobillon and Milcent may be somewhat disappointing. They find an effect of market concentration on the level of quality for the group of non-profit hospitals, but not for the for-profit or the public hospitals. As non-profit private hospitals are more autonomous than their public counterparts, they suggest that managerial autonomy may matter. However, it is difficult to see why they do not observe the same effect in for-profit hospitals with presumably the same autonomy. One possible explanation can be a combination of low price/cost margins, relatively inelastic demand and costs that are strongly positively related to quality. This suggests that the aggregate (system) level type analysis done by Gobillon and Milcent can be supplemented by more specific analysis of how both demand and costs depend on the level of quality.

A final point should be made about competition under administratively set prices. Introduction of activity based financing often leads to better cost information. The need for hospitals to monitor their own costs arises both because they have to compare costs to income, and because the administratively set prices often are calculated from historical (average) hospital costs. In light of the notion of reservation quality as a competitive strategy, we might see excess overall capacity and corresponding excess costs in hospital markets that are competitive. As long as excess costs are absorbed in the administratively set prices, this strategy will be viable from the point of view of the hospital, but hardly from a societal point of view. This will be difficult to detect in studies such as the one of Gobillon and Milcent, in which there is no price differentiation. It does however point at the potential for comparative cross-national studies.

Final Remarks

Most health care systems seek to find a balance between planning and regulation on the one hand and competition and financial incentives on the other. Competition, it seems, does not lead to any substantial increase in quality in France. Gobillon and Milcent suggest that poor information may be one explanation for this. They may be right, but this analysis points to the need for a better understanding of what factors primarily drive our (or our referring doctors') choice of hospitals. One important message from the papers in this volume is that the notion of the informed consumer—a necessary condition for any market to function—is difficult to recognise in an area as complex as hospital care.

The three first papers show that competition between hospital under fixed prices is not a trivial issue, as the allocation of resources (quality of care choice) depends on the particular features of the type of care provided and on the fixed price (that determines the existing margin). Conditional predictions on the impact of competition on quality of care require definition of what the meaning of competition is (more hospitals, higher elasticity of demand to quality, etc.) and the measurement of crucial magnitudes. Both theoretically and empirically one does not obtain general presumptions. In addition, the use of simple indicators and mechanisms (like uniform prospective prices) may be misleading about relative efficiency of hospitals, as mandates to some hospitals (and not forced on others) and patients' characteristics and selection will influence market distribution of patients. This poses important challenges for policy making regarding introduction of competition. Either there is compelling evidence on the crucial parameters before, or a clear risk of unexpected results is present. But the evidence needed may not be available without experiments introducing competition. Not introducing competition has the risk of forgoing the benefits it may bring in some cases. For policy makers, caution is the key word. That is, introduction of competition needs to be closely monitored, and according to observed results readjustments may be required. The set of papers in this volume illustrates the theoretical and empirical difficulties with the analysis of competition between hospitals (under fixed prices).

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Glossary[1]

Allocative efficiency: For given levels of input prices, allocative efficiency means that the combination of inputs is optimized in order to minimize production costs.

Altruistic preferences: Hospital motivation to provide quality due to doctors' desire to improve patients' health.

A pro-competition reform: A reform that provides more incentives for hospitals to compete against each other by increasing their quality and/or by decreasing their prices (depending on the constraints imposed by the healthcare system).

Cost sharing: Cost sharing combines prospective and retrospective payments. It is another name for mixed payment (see below). The idea is that the risk of higher costs due to patients with conditions of great severity is partly borne by the regulator through the portion of retrospective payment.

Demand elasticity: A measure of how much the quantity demanded will change with respect to the change of one factor explaining demand. An example is the price elasticity of demand, which measures how the quantity demanded changes with price.

Diagnosis related groups (DRG): In prospective payment systems, the price schedule is based on a classification of stays in Diagnosis Related Groups and hospitals receive a fixed price per stay in a given DRG. The DRG classification has been set up in the USA by the Health Care Financing Administration. The general principle is to characterize stays prospectively, i.e. on the basis of the diagnosis at the time of admission, irrespective of procedures that are subsequently implemented. In reality, a large proportion of DRGs are based on procedures.

Economies of scale: This is a result of increasing returns to scale; the amount of resources used per unit of output falls at higher levels of output. It implies a

1. All the authors of this volume contributed to this glossary. Many definitions are applications of general concepts in microeconomics to the context of hospital competition as used in the health economics literature.

falling unit cost as output increases, as long as input prices do not increase so as to offset the scale effect.

Economies of scope: These enable a firm to produce several goods or services jointly more cheaply than producing them separately. The simultaneous production of hospital care and medical teaching is an example.

Efficiency rate: This is equal to the ratio of actual production to the maximal possible production, for a given level of input. An efficiency rate equal to 80% means that hospital production is equal to 80% of the possible level of production.

Fixed-price model: Reimbursement of health care providers (such as hospitals and physicians) on a schedule determined by the government; in this case, hospitals consider prices as given.

Herfindahl-Hirschmann Index (HHI): This index measures hospital concentration within a given area. It is defined as the sum of the squares of the market shares of the hospitals within the area, with market shares expressed as fractions. It varies between the inverse of the number of hospitals in the area and 1. The higher the index, the more concentrated the hospital care market. This index is often used to measure the intensity of competition which is considered to decrease the more concentrated the market.

Hotelling model: This is a location model of competition, where the patient cares about the geographic location of the hospital (time and transportation costs to reach the hospital), in addition to the quality of care. The Hotelling model supposes that patients are uniformly distributed on a unit line and that hospitals are located at the extremes of the unit line.

Increasing marginal cost of treatment: The cost of treating a patient increases with the total number of patients.

Intrinsic motivation: Hospital motivation to provide quality due to doctors' self esteem or a concern for reputation.

Logit Concentration Index (LOCI): This index captures the potential market of a hospital within a given area. It varies between zero and one; the higher the index, the larger the potential market. This index is sometimes used to measure the eagerness of hospitals to compete against each other, as this eagerness can be considered to depend on the extent of the potential market. The LOCI can be used to capture market power even when prices are fixed and hospitals compete on the basis of quality.

Mixed payment system: The payment combines a fixed price with partial reimbursement of the actual cost of treatment, i.e. the payment is a mix of prospective and retrospective payments.

Moral hazard: In the context of hospital payments, moral hazard refers to the fact that hospital managers can reduce their effort to minimize costs.

Medicare program: The Federal Health Insurance Program in the USA for people who are 65 or older, certain younger people with disabilities, and people with End-Stage Renal Disease (permanent kidney failure requiring dialysis or a transplant).

Pay-for-performance (P4P): Additional payments based on meeting targets linked to quality indicators.

Price-cost margin: The difference between the tariff received by the hospital to treat a patient and the marginal cost of treating the patient.

Production function: This function gives the maximum level of output that can be obtained for a given level of inputs.

Productive efficiency: A hospital is fully efficient if its production is situated on its production function.

Productivity: The volume of output obtained per unit of input used. For instance, in the case of hospital services, productivity can be defined as the quantity of hospital care provided per bed.

Programme de médicalisation des systèmes d'information (PMSI): A French program established in 1991 according to which public and private hospitals have to record procedures and diagnosis for each patient-stay, and transmit the related information to state services. Information on inpatient hospital stays is centralized and can be used for statistical analysis.

Prospective payment system: A system that pays hospitals a fixed price per stay in a given diagnosis-related group (DRG), irrespective of each hospital's actual cost. This provides a powerful incentive for managers to minimize costs.

Reaction function: The quality response of a hospital in reaction to a change in quality on the part of a rival hospital (in the case of competition on quality).

Retrospective payment: A payment per stay equal to the reimbursement of the actual cost of treatment.

Risk adjustment: A method for determining whether patient characteristics require higher utilization of medical services. Risk adjustment makes it possible to compare mortality rates in two different hospitals, even if the characteristics of their patient populations differ significantly. For example, one hospital may have an older population than the other. This will probably lead to higher mortality rates, not because care quality at the first hospital is inferior, but simply due to the age of the population that receives care there. Once mortality rates at the two hospitals are risk adjusted, the only difference that remains between the two populations, in theory, is the quality of care at the two hospitals.

Salop model: A location model of competition, where the patient cares about the geographic location of the hospital, in addition to the quality of care. The Salop model supposes that patients are uniformly distributed over a circle and hospitals are equidistantly located.

Sluggish demand adjustments: Slow demand responsiveness to increases in quality of a given hospital due to patients' habits or poor observability of quality.

Supplier Induced Demand: The effect that physicians, as the providers of service, may have by creating more patient demand than there would be if they acted as perfect agents for their patients.

Soft budget: When a hospital runs a deficit, governments tend to bail out the hospital.

Stochastic frontier analysis: The production function is the frontier defined by the maximal production levels that can be obtained for given levels of inputs. Stochastic frontier analysis is an econometric method that enables an identification and estimation of efficiency rates, through the specification of a random variable equal to the distance between observed levels of production and the frontier.

Tarification à l'activité (T2A): A reform that gradually introduced a prospective payment system in France beginning in 2004. Before the reform, public hospitals were funded under a global budget system, and private for-profit hospitals were reimbursed on a fee-for-service basis. Since the reform, both public and private hospitals have been funded using a DRG based payment system.

Yardstick competition: An industrial regulatory procedure under which the regulated price is set at the average of the estimated marginal costs of firms in the industry. If differences in costs between hospitals are caused only by moral hazard, a yardstick competition rule of payment offers each hospital a lump sum payment per stay defined on the basis of average costs observed in other hospitals for stays in the same diagnosis-related groups (DRG). This system mimics competition on a free market in order to provide incentives for efficiency gains.

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