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Does Competition Improve Public Hospitals' Efficiency? Evidence from a Quasi-Experiment in the English National Health Service

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Abstract

This paper uses a difference-in-difference style estimation strategy to test separately the impact of competition from public sector and private sector hospitals on the efficiency of public hospitals. Our identification strategy takes advantage of the phased introduction of a recent set of substantive reforms introduced in the English NHS from 2006 onwards. These reforms forced public sector health care providers to compete with other public hospitals and eventually to face competition from existing private sector providers for care delivered to publicly funded patients. In this study, we measure efficiency using hospitals' average length of stay (LOS) for patients undergoing elective surgery. For a more nuanced assessment of efficiency, we break LOS down into its two key components: the time from patients' admission to the hospital until their surgery and the time from their surgery until their discharge. Here, pre-surgery LOS serves as a proxy for hospitals' lean efficiency. Our results suggest that competition between public providers prompted public hospitals to improve their productivity by decreasing their pre-surgery, overall and post-surgery length of stay. In contrast, competition from private hospitals did not spur public providers to improve their performance and instead left incumbent public providers with a more costly case mix of patients and led to increases in post-surgical LOS.

Keywords: Hospital competition, market structure, prospective payment, incentive structure
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1. Introduction

There has been vigorous debate over the theoretical justification and empirical support for expanding competition between health care providers.[1] Nevertheless, despite the ambiguous evidence on the effect of hospital competition on providers' quality and efficiency, a number of countries have recently enacted market-based reforms designed to create financial incentives for health care providers to improve their performance (Gaynor and Town, 2011).[2] In addition to expanding competition between large public hospitals, several of these countries have also promoted the entry of focused, privately owned specialty hospitals to encourage even more competition.[3] This begs two key questions. First, does increased competition between public hospitals prompt providers to improve their productive efficiency? Second, if some competition between large public hospitals is desirable, is adding more competition from private specialist hospitals even better? To answer these questions, this paper examines the impact of a recent set of substantive market-based reforms in the English National Health Service (NHS) that expanded patient choice and forced public hospitals to compete against one another from 2006 onwards and later allowed private sector providers to enter the market and compete to deliver care to NHS-funded patients.

In what follows, we create a quasi-natural experiment using difference-in-difference regression to examine whether hospitals located in more *potentially* competitive elective care markets showed greater improvements in efficiency after patient choice and provider competition were introduced in 2006. Our difference-in-difference research design and our access to detailed patient-level data allows us to expand on the previous research on hospital competition and obtain causal estimates on the effect of public sector competition on providers' efficiency (Angrist and Pischke, 2010). Likewise, the phased introduction of these reforms in England also allows us to test separately whether the 2008 entrance of private sector providers into the market for NHS care also stimulated further improvements in

[1] For example, see a recent debate on competition in the NHS between Mays (2011) and Stevens (2011) that was printed in the British Medical Journal.

[2] These have included market-based reforms in the UK, the Netherlands, Denmark, and Australia.

[3] For a discussion of the private market in England, see Cooperation and Competition Panel (2011). The entrance of specialist hospitals has also been seen in the US, the Netherlands, Canada and Germany.

incumbent hospitals' efficiency or instead if these private providers cherry-picked patients who were less expensive to treat.

The existing literature assessing the impact of hospital competition on providers' efficiency has been hindered by two distinct limitations. The first is that most research in this area has had to assess the effect of competition by examining the relationship between hospitals' efficiency and cross-sectional variation in hospital market concentration (Gaynor, 2006). However, as Kessler and McClellan (2000) have noted, hospital market concentration may be endogenous to hospital performance both in the cross section and over time. Here, high quality providers may deter potential competitors from entering the market, making these markets appear less competitive.

To overcome this issue, we benefit from two sources of exogenous variation in England that aid us in identifying the impact of public sector and private sector hospital competition on incumbent public hospitals' efficiency. First, we examine a policy change (the introduction of patient choice and hospital competition) that was introduced in England and that applied across the country. However, we can exploit the fact that these reforms would not have had a universally strong impact across England and should have had a more pronounced effect in areas where the pre-reform market structure was less concentrated. Second, we benefit from the fact that public and private hospital locations in England are historical artifacts and are therefore unrelated to hospital efficiency. In sum, this research design allows us to determine whether hospitals located in less concentrated markets prior to the UK government's market-based reforms differentially improved their efficiency relative to hospitals located in more concentrated markets, after public competition was introduced in 2006 and private sector competition was introduced in 2008.

The second limitation in the prior hospital competition literature is that in the absence of hospital cost data, many studies have sought to measure hospital efficiency using proxy measures like hospitals' length of stay (LOS) for elective and emergency care (Fenn and Davies, 1990, Martin and Smith, 1996, Gaynor et al., 2010). The underlying logic for this measure is that if hospitals can maintain quality and deliver care within a shorter period of time, this is evidence of improvements in efficiency. However, rather than improving their efficiency, hospitals could shorten their overall LOS by skimping on quality and discharging patients 'sicker and quicker'. Likewise, because overall LOS is heavily dependent on patient characteristics (which directly influence recovery time), hospitals could also appear to shorten their LOS by avoiding high risk patients and focusing their care on patients who are likely less costly to treat or alternatively discharging patients before it is clinically appropriate (Epstein et al., 1990, Martin and Smith, 1996, Sudell et al., 1991).

To address these issues and differentiate between genuine productive efficiency gains and quality skimping, we disaggregate LOS into its two key component parts: 1) the time from the patient's admission until surgery; and 2) the time from the patient's surgery until discharge. Here, pre-surgery LOS will be less biased by patient characteristics and will be largely determined by hospitals' admissions and surgical theatre utilization policies. Indeed, according to the NHS Institute for Innovation and Improvement, pre-surgery LOS should be a strong proxy for efficiency that captures lean production (NHS Institute for Innovation and Improvement, 2006, NHS Institute for Innovation and Improvement, 2008a). In contrast, post-surgery LOS could be driven by skimping and may reflect variation in patients' recovery time. In addition, to assess whether our results are a function of efficiency gains or effort by hospitals to avoid certain patients, we test whether hospitals facing greater amounts of competition from the public and private sector avoided treating more potentially higher cost patients (i.e. older and less wealthy) after competition was introduced in 2006.

Our analysis spans 2002 through 2010 and examines over 1.8 million patient observations. Ultimately, we find that competition between NHS providers from 2006 onwards was associated with reductions in patients' pre-surgery, post-surgery and overall LOS. In addition, we find no evidence that publicly funded NHS hospitals located in more competitive areas were cherry-picking patients who would tend to be less expensive to treat. Conversely, the introduction of private sector competition in 2008 was not associated with improvements in incumbent public hospitals' efficiency. Indeed, ceteris paribus, patients in public hospitals located in areas with more private providers tended to have higher LOS in 2008, 2009 and 2010. This latter finding seems to be consistent with evidence that private sector market entry left incumbent providers treating a more costly case mix of patients who were older and less wealthy. This finding highlights the crucial need for policy-makers to risk-adjust payments as they introduced competition in markets with regulated prices, particularly when there are both public and private providers with different objective functions.

This paper is structured as follows. In section 2, we briefly examine the recent NHS market-based reforms. In section 3, we examine the existing literature in this area, outline our empirical strategy and present our hypothesis. Section 4 includes more information on the data used in this analysis and outlines the measures of market structure we constructed for this analysis. In section 5, we present our results. In section 6, we discuss our findings and present our conclusions.

2. The NHS Reforms

The English NHS was founded in 1948 and is a tax-funded health system that is free at the point of use. The primary care system in England is organized around general practitioners (GPs) who provide patients with referrals for secondary care. Historically, secondary care was mainly delivered in government-owned NHS hospitals that were funded by annual budgets set by the Department of Health (Klein, 2006). From 1992 to 2003, annual hospital budgets were phased out and the government separated the purchasers of care from the providers of care. During this period, hospitals were paid using annual block contracts that were awarded by local purchasing bodies and negotiated on price, which stipulated that providers deliver care to fixed populations (often without minimum activity requirements) (Chalkley and Malcomson, 1998, Department of Health, 2011). Crucially, during this period, patients had little choice over where they received care and they were generally referred by their GP to the hospital with whom their local purchasing body maintained a contract.

In 2002, following the announcement of substantial increases in health care spending, the UK government launched a wave of substantial, market-based reforms to the NHS (Department of Health, 2002). The reforms were introduced on a rolling basis from 2002 through 2008 and were designed to give patients a choice over where they received care and to introduce competition between hospitals within a market with fixed prices (Department of Health, 2004). During this period, the government introduced a range of policies designed to foster a more competitive environment. This included introducing a new fixed-price, prospective payment system, modeled on the Medicare prospective payment system from the United States (Department of Health, 2011). This payment system, known as Payment by Results (PbR), paid hospitals a fee determined by the government, on the basis of patients' diagnoses, with adjustments for local economic wage rates, hospital characteristics and some elements of illness severity. In addition, the government encouraged new private providers to enter the market and gave hospitals additional fiscal and managerial autonomy (including the ability to retain surpluses). These pro-competition policies were set against a backdrop of regulatory reforms designed to guarantee minimum standards of hospital performance.

The key element of the NHS reforms was to give patients a formal choice over where they received secondary care. Together with a reimbursement system where money followed patients around the system, the introduction of choice created financial incentives for hospitals to compete for market share. Beginning in 2002, the government introduced choice pilot programs around the country and gave patients who were waiting for over a year for care (later lowered to nine months) the ability to go to an alternative provider with spare capacity. On January 1, 2006, the government required that all NHS patients referred for elective care be offered a choice of four or more providers (Department of Health, 2009). This was the first point at which the new payment system and patient choice worked in tandem to create financial incentives for hospitals to attract patients. We regard this as the 'policy-on' date where public hospitals faced competition from other public providers in the context of a revenue system rewarding them for higher volume.

The introduction of patient choice was accompanied by the development of a paperless hospital referral system that allowed patients and their GPs to book hospital appointments online or over the phone. The main online interface for the referral system allowed patients and their referring physicians to search for nearby hospitals and included information on providers' performance and information on average waiting times at each facility.

Over time, policy-makers sought to allow patients to access care in the private sector in order to prompt public hospitals to compete with new private entrants. This push for more private provision that is funded by the NHS began with a centrally run program to create privately managed, specialty surgical centers, know as Independent Sector Treatment Centres (ISTCs). These facilities were focused on elective care and were frequently co-located on the grounds of existing NHS facilities (Department of Health, 2005). However, the ISTC program was fraught with problems and by mid-2006, there were only 21 ISTCs established to deliver care to NHS patients (Department of Health, 2006), and the program was eventually heavily curtailed.

Following the limited ISTC program, the government launched a more ambitious push to allow private providers to deliver care to NHS funded patients. This program allowed private providers in England who registered with the government quality regulator[4] to provide care to NHS funded patients. This meant that beginning on a limited basis in July 2007, and in full force from 2008 onwards, all of the 162 private hospitals in England offering elective secondary care with overnight beds were potentially accessible to NHS-funded patients at no charge, if the hospitals agreed to the be paid based using standard NHS tariffs (Cooperation and Competition Panel, 2011). In addition, to facilitate referrals, these hospitals were included on the NHS 'Choose and Book' website and were eligible for paperless referrals from NHS GPs (Department of Health, 2008). In England, the private hospitals account for only 6.5% of the total hospital beds in the country (Boyle, 2011). In general, these private hospitals are similar to private specialty hospitals in the US. These private sector hospitals in England have, on average, fewer than 50 beds and are predominantly focused on delivering elective surgical care (Laing and Buisson, 2011). Of note, unlike public NHS hospitals, these private facilities were allowed to refuse treatment to certain patients based on a set of exclusion criteria that were agreed to with the Department of Health's commercial directorate (Mason et al., 2008). Specifically, private facilities could refuse to offer care to patients whom the providers viewed as having medical conditions that were 'a constant threat to life' or had American Society of Anesthesiologist Scores (severity scores) of 3 or more.[5]

3. Literature Review, Hypotheses and the Specification of Our Empirical Model

Literature Review

Three bodies of research that are informative about the likely response of NHS hospitals to the 2006 introduction of patient choice and provider competition and the 2008 entry of private sector hospitals into the market for NHS funded care. The first body of research

[4] http://www.cqc.org.uk/

[5] ASA 1: Healthy patient with localized surgical pathology and no systemic disturbance; ASA 2: Patient with mild to moderate systemic disturbance (i.e. surgical pathology or other disease process); ASA 3: Patient with severe systemic disturbance from any cause; ASA 4: Patient with life threatening systemic disorder which severely limits activity; ASA 5: Gravely ill patient with little chance of survival.

centers on the impact of prospective fixed price payment on hospital behavior. The second examines the impact of hospital competition on providers' quality. The third assesses the impact of new market entry, including from specialist hospitals, on incumbent hospitals' quality and productivity. In what follows, we will briefly outline this literature and frame our hypotheses.

In isolation, the new payment system in England should reduce length of stay. The new hospital reimbursement system in England is a per-case, prospective payment system that resembles the US Medicare Prospective Payment System (PPS) introduced in 1983 (Frank and Lave, 1985, Lave and Frank, 1990, Manton et al., 1993). Prospective payment should reduce patients' LOS because under this type of payment system, a hospital's net revenue per patient decreases with each additional day of care provided (Cutler, 1995). Consistent with the theoretical literature, there is evidence from various countries that has found that the introduction of case-based, prospective payment systems has led to a reduction in LOS. In the US, several studies, including Feder et al. (1987) and Guterman and Dobson (1986) have found that the introduction of PPS in the US reduced LOS by between 3% and 10%. Similarly, Feinglass and Holloway (1991) and Kahn et al. (1990) found that PPS led to a drop in LOS of over 10%. Evidence on the introduction of prospective payments in Israel in the 1990s mirrors US evidence. Shmueli et al. (2002) found that prospective payment was associated with a significant reduction in LOS, but it did not lead to any statistically significant changes in mortality. Likewise, after the Italian government introduced a DRG-based financing system in 1995, Louis et al. (1999) observed that LOS dropped, with no adverse impact on mortality or readmission rates.[6]

There is some evidence regarding the impact of the prospective payment system introduced in the English NHS from 2003 through 2005. In a recent study, Farrar et al. (2009) conducted a difference-in-difference analysis comparing various outcomes measures in Scotland and England from 2002 through 2006. Unlike England, Scotland did not introduce a prospective funding system from 2003 through 2006. Farrar et al. (2009) found that in England, under a fixed price payment system, LOS fell more quickly and the proportion of day cases rose relative to Scotland. This is the backdrop against which we measure whether there was a differential effect of prospective payment on hospitals located in competitive markets.

[6] For a comprehensive review of the literature on the effect of prospective payment, see Cutler (1995) and Newhouse (2004)

There is evidence that, with respect to clinical quality, hospitals located in less concentrated markets behave differently than hospitals located in concentrated markets when they are exposed to competition (Cooper et al., 2011, Gaynor et al., 2010, Kessler and McClellan, 2000). A growing body of research looking at the impact of fixed price competition on clinical quality in the US and England suggests that in a market with fixed prices, competition catalyzes improvements in clinical performance (Gaynor and Town, 2011). In a widely cited study examining the impact of market structure on quality, Kessler and McClellan (2000) looked at the impact of hospital competition in the US on acute myocardial (AMI) mortality for Medicare beneficiaries from 1985 to 1994. They find that in the 1980s, the impact of competition was ambiguous, but in the 1990s, higher competition led to lower mortality. Using related methodology, Kessler and Geppert (2005) found that competition was not only associated with improved outcomes in their Medicare population, but it also led to more intensive treatment for sicker patients and less intense treatment for healthier patients who needed less care.[7]

In England, recent evidence examining the impact of the introduction of patient choice on clinical outcomes finds similar results. Cooper et al. (2011), an extension of Cooper et al. (2010) use a modified difference-in-difference analysis to analyze mortality from heart attacks and find that hospitals located in competitive markets improved their mortality rates more quickly than hospitals located in less competitive markets after patient choice and hospital competition were introduced nationally in 2006. In their study, the authors find that their results remain consistent across a number of different measures of market structure. Separate work by Gaynor et al. (2010) using a long difference approach also found that competition in the NHS in 2006 was associated with reductions in hospitals' annual overall length of stay and reductions in AMI and overall hospital mortality without concurrent increases in spending. Finally, Bloom et al. (2010) have investigated the effect of hospital competition on management performance of hospitals in the NHS. Using political marginality as an instrument for competition, this study found that hospitals facing

[7] It is important to note that there have been some studies on the impact of fixed priced hospital competition, which have not found positive results. Gowrisankaran and Town (2003) find that hospital competition for Medicare enrollees lowered quality. However, they ascribe their findings to the level at which the administered prices were set. Mukamel et al. (2001) find that hospital competition for Medicare prices has no significant effect.

competition tended to be better managed, which resulted in lower death rates and greater financial surplus.

A related strand of research has examined whether entrants will create competitive pressure that will prompt incumbent hospitals to improve their performance. Cutler et al. (2010) looked at this issue by examining the impact of a policy change in Pennsylvania that rolled back the use of hospital certificates-of-need regulation. This had the effect of allowing more providers to enter the market for coronary artery bypass grafting. The authors analyzed this set of reforms and found that quality improved in markets with a higher share of new market entrants (Cutler et al., 2010). Barro et al. (2006) looked at the impact that new specialty hospitals were having on the costs of care in cardiac care markets in US. Here, the authors found that markets with new entrants had lower rates of cost growth between 1996 and 1999 (Barro et al., 2006).

There is also some work that investigates whether the reforms in the NHS would lead to cherry-picking and risk selection. Here, research suggests prospective fixed price payment systems can create incentives for providers to avoid treating patients whose costs would likely exceed the regulated reimbursement rate (Allen and Gertler, 1991, Ellis and McGuire, 1986, Ellis, 1998b). Indeed, Ellis and McGuire (1986) have found that the introduction of prospective payment in the US was associated with reductions in spending on the sickest patients and Newhouse (1989) found under prospective payment, hospitals tended to select against more costly patients. Ellis (1998) suggested that this risk-selection under prospective payment will likely be more acute in more competitive markets. The lone empirical work in this area is by Meltzer et al. (2002), who used discharge data from California from 1983 to 1993 to examine the impact of competition on hospital costs for low and high cost hospital patients before and after the introduction of the Medicare fee for service payment system in the US. Here, the authors found that there were greater reductions in spending for more costly patients in more competitive areas. They viewed this finding as consistent with the theory that hospitals in more competitive markets under prospective payment would seek to avoid treating more expensive patients (Meltzer et al., 2002).

Additional research has examined whether specialty hospitals (largely analogous to the private providers in England) have tended to attract younger, healthier or wealthier patients. In addition to assessing the impact of cardiac specialty hospitals on quality, Barro et al.

(2006) also examined whether these facilities attracted a relatively healthier patient population. They found that following the entry of specialized providers into the market, these specialty hospitals attracted a healthier patient case mix, leaving the population in incumbent general hospitals with a sicker patient population (Barro et al., 2006). These findings are echoed by other analysis suggesting specialist hospitals tend to cherry-pick more profitable patients (Winter, 2003, Cram et al., 2005, Kc and Terwiesch, Forthcoming). Indeed, there is evidence from England that the first wave of private providers that were in England, known as ISTCs, tended to draw healthier patients for care (Chard et al., 2011, Mason et al., 2008).

Hypotheses

This paper builds on earlier research and examines the impact of public and private sector competition on incumbent public hospitals' efficiency in England. Theory suggests that the introduction of hospital competition and patient choice in 2006 and the entrance of private sector providers in 2008, both within a market with regulated prices, will prompt public hospitals to increase their efficiency (shorten their pre-surgery LOS) (Gaynor, 2006). During our period of analysis, hospital LOS is falling across England. Theory suggests that hospitals located in more competitive markets will produce even sharper declines in LOS after the government's pro-competition reforms were introduced in 2006. Here, changes in pre-surgery LOS would be suggestive of improvements in hospitals' lean production.

We expect these reductions in LOS to stem from improvements in hospital management that are driven by competition. We will be able to capture these improvements in management, driven by competition not only in reductions in overall LOS, but also in reductions in pre-surgery LOS, which are a direct function of hospitals' operating room and admissions procedures. Likewise, beyond the effect of management on LOS, we also hypothesize that hospitals facing greater competition will take additional steps to shorten their LOS because it will 1) allow hospitals to lower their marginal costs per patient thereby generating larger surpluses and 2) it will allow hospitals to free up additional operating room capacity which they can use to treat additional patients in order to increase their revenue, free up space to business steal from competitors and maximize their market share, assuming marginal costs are less than marginal prices.

At the same time,, hospitals facing more substantial pressure to maintain surpluses may face incentives to select patients that they expect to be less costly to treat. Indeed, such fears were expressed about the earlier experience with hospital competition in the NHS in the 1990s (Scheffler, 1989). However, no evidence has shown that hospitals in the NHS engaged in cherry-picking, and we are doubtful that it will occur within the current market (Le Grand et al., 1998). That is because it is unlikely that NHS facilities actually have the ability to refuse treatment to publicly funded patients, since regulators state that NHS hospitals must not refuse treatment and cannot cherry-pick particular patients.

However, consistent with Ellis (1998) and Barro et al. (2006), it is also likely that the entrance of private sector facilities in 2008 will leave incumbent public hospitals facing more private competition with a more costly mix of patients. This outcome is particularly likely because private providers in England are, in contrast to NHS providers, allowed to refuse care to certain patients, largely on clinical safety grounds. Likewise, while all NHS providers face a theoretical incentive to avoid treating patients whose costs are likely to exceed their reimbursement rates, these incentives might be more substantial for private, for-profit facilities with different objective functions than NHS providers.

Empirical Estimation Strategy

Our empirical analysis is focused on using difference-in-difference (DD) regression to test whether patients in more competitive markets had observable changes in their LOS after hospital competition in the public sector was introduced in 2006 and after private sector providers were allowed to compete with NHS from providers from 2008 onwards. As we described in Cooper et al. (2011), the NHS competition reforms that we are studying do not fit precisely within the traditional difference-in-difference framework. That is because the pro-competition reforms were rolled out universally across England and, strictly speaking, there were no wholly treated and wholly untreated groups. However, the intensity to which hospitals are exposed to the reforms will vary on the basis of hospitals' pre-reform market structure. We hypothesize that hospitals located in more concentrated markets pre-reform will be less exposed to pressure from competition post-reform, whereas hospitals located in less concentrated markets will face more competitive pressure after the reforms were introduced. As a result, our identification strategy rests on testing whether patients receiving care at hospitals located in less concentrated markets pre-reform had more marked reductions in their LOS after the pro-competition reforms were introduced. Therefore, our general empirical regression takes the form:

$$\textbf{1)}\quad los_{ijkt} = \alpha + \lambda\ pub\_comp_j + \varphi_2\ priv\_comp_j + \kappa_3\ Post2005_t + \delta_3\ Post2007_t + x_{ijkt}$$
$$+ \beta\,(pub\_comp_j \cdot Post2005_t) + \Omega\,(priv\_comp_j \cdot Post2007_t) + \theta_j + \theta_k + \theta_p + \varepsilon_{ijkt}$$

Here, los_{ijkt} is the length of stay in the hospital of patient *i*, who was referred by GP *k* and received care in year *t* at public hospital *j*. $Post2005_t$ is an indicator variable for whether patient *i* received care after December 31st, 2005 and $Post2007_t$ is an indicator variable for whether patient *i* received care after December 31st, 2007. Our measures of market structure are pub_comp_j and $priv\_comp_j$, which measure public market structure and private market structure respectively.[8] The impact of greater public sector competition post-2005 is captured by β; Ω captures the impact of greater private sector market structure post-2007. The term x_{ijkt} is optionally included and is a vector of patient characteristics that includes 5-year age band dummies, dummies for patients' socio-economic quintile and a gender indicator. In addition, we can include GP, hospital and procedure fixed ($\theta_j + \theta_k + \theta_p$) to control for their time invariant differences.

In this paper, our identifying assumption is that in the absence of the pro-competition reforms, patient outcomes in more competitive areas would have followed similar trends to outcomes that occurred in monopoly markets. Later in this paper, we test this assumption empirically by looking at a non-parametric estimation of (1), where our public and private market structure measures are interacted with year dummies and the estimator includes individual, interacted year dummies. Throughout this analysis, we estimate (1) using Ordinary Least Squares and cluster the standard errors in our estimates at the hospital level within years to allow for error correlation across patients treated at the same facilities.

At its core this estimation strategy is dependent on how we identify hospitals' pre-reform market structure. As a result, to add robustness, as we discuss in more detail below, we identify pre-market structure using counts measured within several different market definitions to illustrate that our findings are consistent across all of our measures of market

[8] As we describe in Section 3, we measure hospital market structure for each GP *k*. These GP-level measures of market structure are aggregated up to hospital level *j*.

structure. These include markets that capture a fixed geographic area and markets that capture fixed populations. In addition to measuring competition using hospital counts, we also create Herfindahl-Hirschman Indexes (HHIs) of market concentration that are based on predicted patient flows based on models of patient choice that are a function of hospital characteristics, patient characteristics and distances between patients and hospitals.

As we discussed earlier, one broad concern within this literature is that any observed measures of market structure are potentially endogenous to hospital performance. Here, for example, a high-performing hospital may appear to be operating in a less competitive market because it has been able to attract market-share from its competitors or even drive them out of the market. Likewise, poorly performing providers may appear to be operating in more competitive markets because their lack of quality and efficiency has encouraged other competitors to enter the market and offer better services to patients at more reasonable prices. However, in England, NHS hospital locations in England are a historical artifact (Klein, 2006). As a result, we view the location of these NHS facilities as exogenous to hospital performance and unaffected by the NHS reforms that were introduced in the 2000s.

Similarly, nearly every private provider in England was founded prior to the expansion of NHS patient choice to private providers in 2008. Indeed, 158 of 162 providers were in existence prior to 2006, 90% were in existence prior to 2000, 72% were in existence prior to 1990 and the mean opening date for private hospitals available to patients in our analysis was 1979. As a result, we also view the location of private providers in England as exogenous to NHS hospitals' performance. Nevertheless, private providers did have a choice about whether or not, as an organization, they offered care to NHS patients. As a result, within our analysis, if we used the count of private providers who actually chose to deliver care to NHS patients, there is a risk that this measure could be endogenous to local NHS performance. Here, for example, private providers could decide to only enter the market for NHS market when they perceived that their local NHS providers were inefficient or were offering a poor level of service. As a result, we base our counts of private hospitals on the number of private providers that were operating in the NHS during this period that *could* have decided to offer care to NHS patients, as opposed to counting those that *actually* did offer care.

4. Data Sources and Our Measures of Hospital Market Structure

This paper relies on patient-level Hospital Episodes Statistics (HES) data from 2002 through 2010. This is a large administrative data set that records nearly every consultant episode delivered in the English NHS.[9] This dataset includes a wide range of information on patients, providers and local area characteristics. In addition, we also use data on the private sector in England that were obtained from Laing and Buisson, a private data holding company in the UK.[10] This data include the name, location, and bed numbers for private providers and the dates that these facilities opened. We limit our analysis to private providers who offer elective care and are eligible to provide care to NHS-funded patients. We have used further micro data on population levels and population density across UK Middle Layer Super Output Areas that were obtained from the Office of National Statistics.[11] These measures were used in the construction of our hospital competition measures. All hospital and GP postcodes were matched to their geographical coordinates using the UK National Postcode Directory.

In our analysis, we focus on elective hip replacements, knee replacements, hernia repairs and arthroscopies performed on patients between ages 18 and 80.[12] We excluded any observations missing admissions or discharge dates and observations that were missing data on patient characteristics. This represented less than 2% of our sample. We also exclude observations with a LOS in the 99th percentile of the distribution, so that our estimates are not influenced by extreme outlying data observations (i.e LOS of over 6 months). We focused on elective hip replacements, knee replacements, arthroscopies and hernia repairs in this analysis

[9] Each HES record is a consultant episode, which we then collapsed to spells (admissions).
[10] http://www.laingbuisson.co.uk/
[11] MSOAs have a minimum population of approximately 5000 and a mean population. For more information, see http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-areas--soas-/index.html.
[12] We defined hip replacements as procedures with an Office of Population, Census and Surveys Classification of Surgical Operations and Procedures 4th Edition (OPCS 4) code of W37.1, W38.1 or W39.1. We defined knee replacements as procedures with an Office of Population, Census and Surveys Classification of Surgical Operations and Procedures 4th Edition (OPCS 4) code of W40.1, W42.1, or W42.1. We defined hernia repairs as procedures with an Office of Population, Census and Surveys Classification of Surgical Operations and Procedures 4th Edition (OPCS 4) code of T20.1, T20.2 or T20.3. We defined arthroscopies as procedures with an Office of Population, Census and Surveys Classification of Surgical Operations and Procedures 4th Edition (OPCS 4) code of W82 through W89.

because they collectively account for a large share of public and private providers' elective activity.

Our dependent variable of interest is the LOS for patients admitted for an elective hip replacement, knee replacement, hernia repair or arthroscopy at an NHS acute hospital between 2002 and 2010. As explained earlier, we divided patients' length of stay in the hospital into two components, pre- and post-surgery LOS, and study the impact of competition on these two measures separately.

Our patient-level data allow us to risk-adjust for clinical severity by controlling for various patient characteristics in our estimates. These patient characteristics include gender, age and socio-economic status measured using the income vector of the 2004 Index of Multiple Deprivations (IMD), measured at the Lower Super Output Area (Department of Communities and Local Government, 2009).

For confidentiality reasons, the patients' home addresses are not available for use in our analysis. However, we do have access to codes that identify the patients' GP and GP postcode. There are approximately 8000 GPs in each year in our data. Patients can usually (at the time of our study) only register at a GP practice if they live in a GP's catchment area, so a patient's GP practice location serves as a good proxy for a patient's home addresses. As a result, we use the distance between a patient's registered GP and their local hospitals as a proxy for the distance between a patient's home address and their local hospitals.

Quantifying Public and Private Hospital Competition

To quantify public and private hospital market structure, we measure counts and HHIs within three separate market definitions (one market of a fixed geographic size and two market definitions based on a size that captures a fixed population). In addition, we also calculate a HHI that is based on predicted patient flows. The counts of hospitals within fixed radius markets are meant to capture the number of hospitals per unit of area. The count of hospitals within the population-defined markets are meant to capture the number of hospitals per people. Our measures of market based on patient flows are designed to capture market concentration based on predicted patient flows that are unrelated to patients actual referral decisions.

We calculate our counts and HHIs at the GP-practice level. This is consistent with the structure of the NHS reforms, where all secondary referrals must flow through patients' GPs and it also is consistent with evidence that shows that patients view GPs as their most important source of information on where to be referred (Dixon et al., 2010). However, since hospitals likely cannot differentiate their services to patients from different GP practices, we aggregate these GP-level competition measures up to a hospital level.

Details on our methodology for constructing our market definitions are as follows. For our fixed radius markets, a radius *r* of 20km was drawn around each GP in England. As a result, circular markets were drawn around each GP, which captured all providers within radius *r* that performed the particular elective procedure being studied. For our fixed population measures, we begin with a matrix of Middle Super Output Areas (MSOAs) in UK, which are predefined geographic areas in the UK that each capture between 5000 – 7000 people. For each MSOA, we calculate the radius that extends from its center out to the distance that would be required to bound a circular area with a population of 333,000 adults over the age of 18, which we measure using data from the 2001 census. We chose these population levels because 333,000 people is roughly the catchment area for each hospital in England, based on the ratio of the current population of adults over the age of 18 in England divided by the number of hospitals in the county. In addition, we also calculate the radius for circular areas around each MSOA that would capture 666,000 people. Then, each general practice in England is assigned a radius, based on the MSOA where it is located. As a result, for each GP in England, we get two radii; one that defines the area around that practice that captures 333,000 adults and one that defines the area that captures 666,000 adults. These radii serve as our market boundaries. In practice, the mean radius defined by our 333,000-person radius is 14.8km and the radii at the 25th and 75th percentile of the distribution are 7.6km and 20.1km, respectively. For our 666,000 person, market the mean radii that defines the market is 22.1km and the radii at the 25th and 75th percentile of the distribution are 11.7km and 29.3km, respectively.

After we have defined our market areas, we measure counts of providers within these fixed radius and fixed population markets. The counts of public health care providers are based on the number of public providers that were offering care in 2002. Our count of private providers is based on the number of providers who could have potentially offered care to

NHS patients in 2008, irrespective of whether or not they actually did offer care. These providers were not ISTCs; they were hospitals included within the Any Willing Provider (AWP) program. Within our sample, there are a small number of GP markets where the various population radii do not capture an NHS provider. For those markets, we extend the radius out to a distance that captures the nearest NHS provider located outside of the market.

In addition to creating counts of hospitals within GP-centered markets, we also created GP-level HHIs using predicted patient flows, similar to Kessler and McClellan (2000). Like Kessler and McClellan (2000), we also generated predicted patient flows based on differential distances, controlling for patient and provider characteristics. Here, we have multiplied our HHIs by -1, so that a higher HHI is associated with less concentration. Details of how these predicted patient flow measures are calculated are included in Appendix 1

Ultimately, we end up with counts and predicted-flow HHIs measured within over 8000 separately defined markets in England that are each centered on GP practices. In order to get hospital-level measures of market structure, we aggregate our measures up to the hospital level *j*, weighted by the distance from GPs to hospitals for all GPs *k* within 60km of hospital *j*, such that:

3) $$comp_j = \sum_{k=1}^{N} \frac{comp_k}{distance_{jk}} .$$

This aggregation creates hospital-level competition measures that are the average of the GP-level demand functions. Crucially, our distance weighting means that a hospital's market structure will be more heavily influenced by the demand functions of its nearby GP markets.

5. Results

Our analysis included 1,882,750 patients who were treated at 161 public NHS hospitals and received referrals for care from 8,024 separate GP practices. During the latter three and a half years of our analysis, there were 162 privately owned facilities that were potentially accessible to the NHS-funded patients in our sample. From 2002 through 2010, LOS in England fell substantially. Table 2 illustrates that during that period, overall LOS fell by 32.4% and pre-surgery LOS fell by 77.6%. Indeed, by 2010, patients were 41.7% more likely to receive surgery on the day that they were admitted to the hospital than they were in 2002. These broad reductions in pre-surgery, post-surgery and overall LOS were likely the result of the government's introduction of a fixed price prospective payment system (Farrar et al., 2009). It is against this backdrop that we are carrying out our analysis to determine whether hospitals located in less concentrated markets pre-reform had more substantial reductions in LOS post-2006, when public hospitals were forced to compete against one another, and post-2008, when incumbent public hospitals faced competition from the private sector. Because we do not have data on patients treated in the private sector, our analysis focuses exclusively on the LOS of patients treated in public facilities during this period.

Table 3 presents estimates of equation (1) on overall LOS and examines whether hospitals located in less concentrated public and private markets, based on the count of hospitals in those markets and predicted flow HHIs, improved their performance after these pro-competition reforms were introduced. Table 3 presents estimates of (1) across four measures of market structure, with and without hospital and GP fixed effects and patient characteristics. A negative term on the interaction between public market structure and our post-2006 indicator suggests that hospitals in less concentrated (more competitive) markets pre-reform reduced their LOS after the NHS pro-competition reforms were introduced (recall that this is because we have multiplied our HHI by -1 so that it increases as concentration decreases).

Across each specification, hospitals located in less concentrated markets pre-reform reduced their overall LOS from 2006 onwards, after they were exposed to the financial incentives created by the government's market-based reforms. To benchmark the magnitude of our effects, a one standard deviation decrease in market concentration pre-reform was associated with a reduction in overall LOS of between 2% and 6% relative to the mean LOS over that period. Of note, a 1 standard deviation increase in our public count measured within a 333,000-person radius produces approximately the same effect as a 1 standard deviation increase in our predicted HHI (i.e. more competitive and less concentrated). Framed differently, the addition of one hospital to a hospital market lowered the LOS for patients treated in that area by approximately 0.4 days (or approximately 16.6% off of mean LOS during our study period). All our results are robust with and without GP and hospital fixed effects and with and without patient characteristics.[13]

While we observe that public sector competition reduces LOS post-2006, we find the opposite result from private sector competition. From 2008 onwards, a 1 standard deviation lower pre-reform private sector market concentration is associated with 2-2.7% relative increase in the length of stay for patients treated at public hospitals. This result is also robust across each of our measures of market structure and remains positive and significant with and without fixed effects and controls for patient characteristics. As we will explore later, this finding is potentially suggestive that private providers are cherry-picking less costly patients away from public incumbent hospitals.

Figure 1 presents the yearly impact of public hospitals' market concentration on patient's overall LOS, where market structure is measured using the count of NHS hospitals within our 333,000 person markets.[14] This figure is constructed from the coefficient estimates presented in Appendix 2. These results demonstrate that the impact of hospital competition occurred after the period that these pro-competition reforms were introduced in 2006. Figure 1 validates our difference-in-difference strategy and illustrates that competition had virtually no effect on overall LOS prior to 2006. In contrast, higher competition was associated with reductions in LOS from 2006 onwards. Table 4 presents several tests of robustness for the results we presented in Table 3. Results from Column 1 from Table 4 suggest that competition had a beneficial impact outside of London and that lower market concentration (higher competition) was associated with lower LOS when we excluded patients treated in London from our analysis. Columns 2 and 3 test whether foundation trusts (high performing NHS hospitals) and teaching hospitals had differential improvements in LOS from 2006 onwards. Columns 2 and 3 demonstrate that even with these additional controls, our main results stay consistent with what we observed in Table 3. These results are important to demonstrate because if foundation trusts and teaching hospitals were more likely to be located in less competitive markets and they were differentially impacted by other policy changes during this period, then they could be spuriously driving our results. Column (5) tests whether the LOS for patients treated in public hospitals exposed to more competition from the government's initial attempts to expand the supply of private providers were

[13] All of our results are also robust when run at the hospital level using robust standard errors.
[14] Results for the year * competition interactions are presented in Appendix 2.

impacted by the reforms. These results suggest that the impact of this minor wave of hospital entry mirrored the trends we observed from 2008 onwards. These results are consistent with existing evidence that suggests that these independent sector treatment centers tended to draw a healthier case mix of patients in comparison to traditional tertiary hospitals (Chard et al., 2011).

While we consistently observe that patients treated in public facilities facing more competition from 2006 onwards had shorter overall LOS, our earlier discussion observed that we are aware that these results could be a function of changes in hospitals' policies that result in patients getting discharged from the hospital 'sicker and quicker'. To address these concerns and get a more nuanced assessment of the impact of competition on patients' LOS, Table 5 presents estimates of (1) on patients' pre-surgery and post-surgery LOS. Note that improvements in pre-surgery LOS cannot be a function of hospital discharge policies. Instead, they likely reflect improvements in hospitals' admissions policies and operating room management, which reduce the turn around time between patients (NHS Institute for Innovation and Improvement, 2008a). Table 5 illustrates that hospitals located in less concentrated (more competitive) markets achieved more pronounced decreases in both patients' pre-surgery LOS and post-surgery LOS after hospital competition was introduced in 2006. Indeed, the relative impact of competition was actually greater on pre-surgery LOS than post-surgery LOS.

Our results suggest that a 1 standard deviation decrease in concentration pre-reform was associated with a 3-9% relative reduction in pre-surgery LOS, relative to the mean, after the reforms were introduced. These findings suggest that the hospital competition resulted in reductions in patients' LOS that were driven by genuine improvements in lean production, rather than changes in hospitals' discharge policies that sent patients home before it was clinically appropriate. Tables 6 and 7 suggest that these results hold across a number of tests of robustness, and Figure 2 illustrates that the improvements we see in pre-surgery largely occurred after hospitals were forced to compete from 2006 onwards.

The Department of Health in the UK has estimated that each excess bed day for an elective admission in the NHS costs the health service approximately £225.00 (NHS Institute for Innovation and Improvement, 2008b). As a result, reductions in LOS should produce substantial monetary savings for the health service. Table 6 suggests that hospitals located in a 1 standard deviation less concentrated market prior to 2006 reduced their pre-surgery LOS by 9.9% from 2006 onwards. However, since pre-surgery LOS is generally quite short, this reduction amounted to approximately a one-hour reduction in pre-surgery LOS for each patient. Therefore, it is unclear whether these reductions in LOS resulted in fewer total bed days spent in the hospital. In order to determine whether reductions in pre-surgery LOS resulted in less bed days in the NHS, Table 8 presents estimates of (1) on whether or not patients underwent surgery on the day they were admitted to the hospital. Here, results from Table 8 suggest that hospitals more exposed to public sector competition increased the rate that patients treated in their facilities had surgery on the day that they were admitted to the hospital. Estimates from Table 8 suggest that a one standard deviation reduction in market concentration pre-reform was associated with a 2-4% increase in the rate that patients had surgery on the day of their admission.

Evidence of Public and Private Sector Competition Altering the Case Mix of Patients Receiving Care at Public Facilities

As we have discussed, there is reason to suspect that hospital competition together with prospective payment could create incentives for providers to avoid treating patients who are potentially more costly to treat. This could influence our results in two key ways. First, if public providers engaged in cherry picking, this could undermine our argument that hospital competition between public providers induced improvements in efficiency from 2006 onwards. Second, if private providers engaged in cherry-picking, this could help explain why the 2008 entrance of private sector providers into the market for NHS funded care was associated with increasing LOS in hospitals located in areas with more private providers.

To test whether public or providers cherry-picked healthier patients for care post-reform, we run estimates of (1) where we place patient characteristics on the left-hand side of our estimation. This allows us to observe whether higher public and private sector competition was associated with changes in the case-mix of patients treated in public hospitals from 2006 onwards.

Table 9 presents estimates of the effect of public and private hospital market structure on the age of patients at incumbent facilities. Two clear results emerge. First, public hospitals located in less concentrated (more competitive) markets pre-reform did not have a statistically significant change in the age of their patients post reform. This suggests that they did not avoid treating older patients. In contrast, there is some evidence that NHS hospitals located in areas with a more robust private sector tended to treat older patients post reform. We take this as indicative of risk-selection.

Building on these results, Table 9 presents estimates of (1) where we observe whether pre-reform market structure was associated with changes in the socio-economic status of patients treated in public hospitals post-reform. Results from Table 9 illustrate that hospitals located in less concentrated markets post-reform tended to treat older patients. This suggests that the reductions in LOS that we previously observed were a function of improvements in hospital efficiency, rather than risk-selection. In contrast, consistent with our results from Table 9, results from our estimates of (1) on patients' socio-economic status suggest that hospitals located in areas with more private providers tended to treat a less wealthy mix of patients after private sector competitors entered the market for NHS care from 2008 onwards. Taken as a whole, results from Tables 9 and 10 suggest that private sector competition from 2008 onwards failed to stimulate efficiency gains in the public sector because they left public providers treating a more costly mix of patients.

6. Discussion and Concluding Thoughts

Over the last decade, policy-makers in England have introduced a series of reforms to the NHS that were designed to use patient choice and provider competition in an effort to create financial incentives for public sector health care providers to improve their performance (Department of Health, 2004). These efforts are consistent with the increasing use of market-based reforms in public services, like health care and education, across the developed world (Hoxby, 2000; Cutler, 2002).

Thus far, evidence suggests that the impact of this set of reforms in the English NHS improved clinical quality. Several studies have found that, consistent with theory, the introduction of fixed price hospital competition has lowered hospital mortality rates and shortened hospitals' overall length of stay (Cooper et al., 2011, Gaynor et al., 2010). However, there is little evidence on whether these reforms have led to efficiency gains and little analysis of the impact that private providers have had on the performance of incumbent public hospitals. Likewise, outside of England, the evidence of the impact of competition on providers' efficiency remains murky, and there is little firm evidence on whether or not competition induces hospitals to avoid treating potentially more costly patients (Ellis, 1998a, Meltzer et al., 2002).

This paper seeks to fill this evidence gap. In this study, we utilize patient-level data from the English NHS to not only examine the impact of public and private sector performance on public hospitals' productive efficiency, but to also examine whether the combination of the new prospective payment system together with public and private sector competition led providers in England to avoid treating patients who might have higher than average costs.

From an empiricists' perspective, the recent policy reforms in the English NHS provide an ideal environment to test the impact of public sector and private sector competition on incumbent hospitals' performance. First, unlike the case of hospitals in the US, the location of public and private hospitals in England is an historical artifact. As a result, this allows us to develop measures of market structure that are unrelated to performance. Second, recent reforms in the NHS have been introduced universally across the country. This allows us to avoid concerns that the policies we are studying were endogenous to regional pre-reform trends in hospital performance. Third, the phased introduction of the reforms in England (i.e. public competition in 2006; private competition in 2008) means that we can identify separately the effect of public sector versus private sector competition on incumbent NHS hospitals. Finally, our data provides an outcome variable – patients' pre-surgical length of stay – that was noted by the NHS Innovation Institute to capture hospitals' lean production (NHS Institute for Innovation and Improvement, 2008a, NHS Institute for Innovation and Improvement, 2008b).

The results from our analysis suggest that competition between public sector hospitals from 2006 onwards led to moderate but statistically significant reductions in pre-surgery, post-surgery and overall LOS. We estimate that hospitals located in markets that were 1 standard deviation less concentrated pre-reform shortened their pre-surgery LOS by approximately 9% and their overall LOS by 5% relative to the mean from 2006 onwards over and above the downward tend in LOS present during this period. These reforms also raised the rate that that patients received care on the day the entered their hospital by approximately 4%. Our estimates were robust across a number of specifications and measures of competition. There was no evidence that these reforms induced public hospitals to discharge patients ‘sicker and quicker’ and no evidence that they spurred public hospitals to avoid treating older and less wealthy patients. To the contrary, as public competition in the NHS took force, NHS hospitals facing more competition also tended to treat patient populations that had a higher share of less wealthy patients.

While the impact of competition between public sector firms led to clear productivity gains, the policy of opening up NHS markets to private sector competition did not. Incumbent NHS providers located in more competitive hospital markets actually saw their LOS increase after competition with the private sector took force from 2008 onwards. Our result suggests that private sector market entrants may have attracted a healthier patient population and left incumbent public hospitals with a patient case mix that is more costly to treat. Consistent with this assertion, further evidence from our work suggests that incumbent hospitals in more competitive private markets saw the average age and proportion of poorer patients in their case mix increase after competition took force in 2008.

It is unclear from our analysis whether or not private sector providers actively avoided treating less costly patients or whether these results stem from healthier and younger patients choosing to receive care in the private sector. Nevertheless, our results do suggest that more attention needs to be paid in England to suitably risk-adjusting payments for both public and private sector providers. Elsewhere, Barro et al. (2006) found that while privately owned specialty hospitals tended to draw healthier patients away from incumbent general hospitals, the entrance of these facilities still led to a net reduction in overall spending in these markets. Seemingly this was because the entrance of these new providers induced broader productivity gains that led to market-wide improvements in efficiency that swamped any losses from cream skimming. This certainly could still be the case in the NHS, but given that we failed to see that private sector competition led to reductions in pre-surgery LOS for incumbent public hospitals, this assertion cannot be asserted empirically.

The conclusion then is twofold. First, our findings demonstrate that hospital competition can lead to improvements in public providers’ productivity based on our observed reductions in hospitals pre-surgical LOS. Here, if we assume that the impact of competition on pre-surgery LOS captured overall improvements in hospital efficiency, then these 7-9% gains would have produced non-trivial savings. However, we also find that the underlying market dynamics and the specifics of the hospital payment program in place can greatly affect the impact of competition. While we did find that competition improved providers' productivity, we also found that that there is a real risk that hospital competition between public and private providers and between general hospitals and specialty surgical centers can lead to risk segmentation, with large incumbent hospitals at risk of inheriting a riskier patient case mix who are more costly to treat. This, in and of itself, may not reduce social welfare. However, our results suggests that in order to maximize the welfare gains from these types of market-based reforms, policy-makers must investigate and introduce more sophisticated risk-adjustment of hospital payments to control for variation in patients' prospective costs and limit hospitals' ability to create excess profits by focusing on healthier patients.

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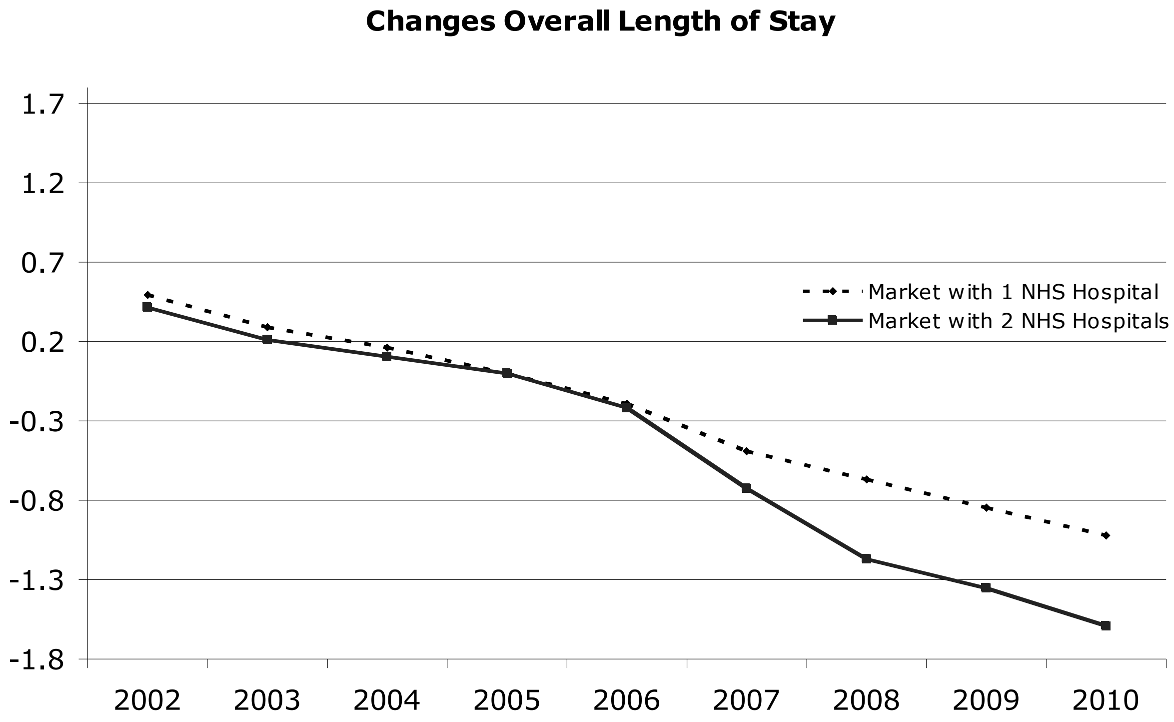
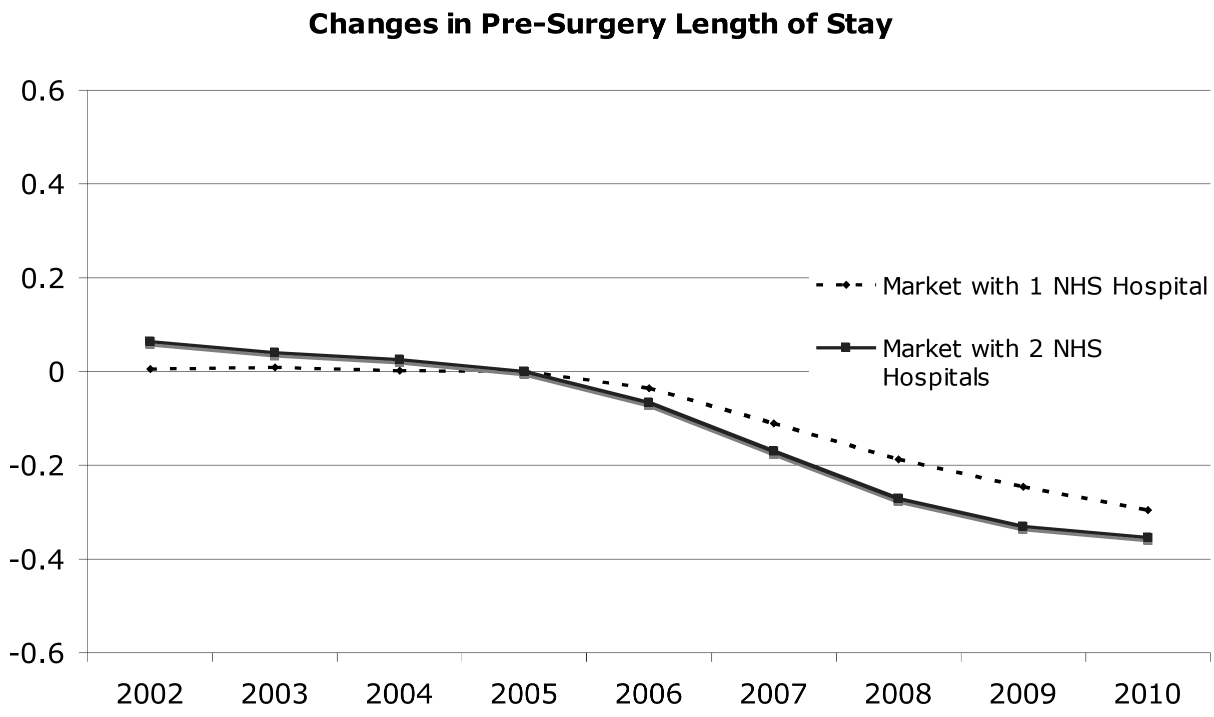
Figure 1: Changes in overall LOS for patients treated in public hospitals located in monopoly markets (dashed line) and overall LOS for patients treated in hospitals that face competition from an alternative provider (solid line).



Notes: the plot is normalized to zero in 2006

Figure 2: Changes in pre-surgery LOS for patients treated in public hospitals located in monopoly markets (dashed line) and overall LOS for patients treated in hospitals that face competition from an alternative provider (solid line).



Notes: the plot is normalized to zero in 2006

Table 1: Descriptive statistics for key variables

	Mean	S.D.	Min	Max
Pre-Surgery LOS	0.244	0.513	0.000	7.000
Same-Day Surgery	0.778	0.4153	0.000	1.000
Post-Surgery LOS	2.179	3.1628	0.000	17.000
Overall LOS	2.411	3.430	0.000	17.000
Count of public providers within 333k population radius	1.230	0.3763	1.000	3.371
Count of private providers within 333k population radius	1.110	0.3598	0.126	2.586
Count of public providers within 666k population radius	2.192	0.3980	1.344	3.445
Count of private providers within 666kk population radius	2.121	0.6110	1.068	4.866
Count of public providers within 20km fixed radius	5.866	5.94	1.000	20.373
Count of private providers within 20km fixed radius	5.525	5.81	0.016	20.505
Predicted HHI	-0.524	0.1560	-0.970	-0.311
Income Vector of the 2004 Index of Multiple Deprivations	0.135	0.1080	0.000	0.960
Female	0.388	0.4872	0.000	1.000
Age	56.076	15.6398	18.000	79.000
Hospital located in urban area	0.772	0.4193	0.000	1.000
Hospital located in London	0.122	0.3271	0.000	1.000
Foundation Trust Status	0.248	0.4321	0.000	1.000
Teaching Status	0.119	0.3238	0.000	1.000

Table 2: Yearly means of pre-surgery LOS, the same-day surgery rate, post-surgery LOS and overall LOS

	Pre-Surgery LOS	Same-Day Surgery Rate	Post-Surgery LOS	Overall LOS
2002	0.376	0.6543	2.605	2.981
2003	0.373	0.6563	2.501	2.874
2004	0.355	0.6733	2.400	2.755
2005	0.321	0.7064	2.261	2.582
2006	0.273	0.7510	2.154	2.427
2007	0.200	0.8162	2.038	2.238
2008	0.144	0.8696	1.927	2.070
2009	0.115	0.8952	1.970	2.086
2010	0.084	0.9273	1.930	2.014
Percentage change from 2002 - 2010	-77.66%	41.72%	-25.91%	-32.44%

Table 3: Least-Squared Estimates of (1) on Patients' Overall Length of Stay

	(1) Coef. S.E.	(2) Coef. S.E.	(3) Coef. S.E.	(4) Coef. S.E.	(5) Coef. S.E.	(6) Coef. S.E.
Post 2005	-0.131 (0.152)	-0.150 (0.152)	-0.144 (0.117)	-0.353*** (0.101)	-0.594*** (0.029)	-0.948*** (0.068)
Post 2007	-0.431*** (0.073)	-0.442*** (0.074)	-0.429*** (0.055)	-0.481*** (0.066)	-0.326*** (0.028)	-0.348*** (0.027)
Public Comp	0.405*** (0.085)	0.367*** (0.084)	-	-	-	-
Private Comp	-0.067+ (0.037)	-0.057 (0.037)	-	-	-	-
Post 2005 * Pub. Comp	-0.389** (0.120)	-0.394** (0.120)	-0.396*** (0.093)	-0.127** (0.044)	-0.006* (0.003)	-0.604*** (0.122)
Post 2007 * Priv. Comp	0.154** (0.060)	0.158** (0.060)	0.153*** (0.043)	0.105*** (0.029)	0.012*** (0.003)	0.016*** (0.003)
Patient Char.	No	Yes	Yes	Yes	Yes	Yes
Hospital F.E.	No	No	Yes	Yes	Yes	Yes
Public Comp Measure	Count within 333 population market	Count within 333 population market	Count within 333 population market	Count within 666 population market	Count within 20km Fixed	Predicted Flow HHI
Private Comp Measure	Count within 333 population market	Count within 333 population market	Count within 333 population market	Count within 666 population market	Count within 20km Fixed	Count within 20km Fixed
Obs	1882750	1882750	1882750	1882750	1882750	1882750
R-Squared	0.738	0.749	0.756	0.756	0.756	0.756

Notes: Dependent variable is patient's overall length of stay. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Tests of the robustness of least squared estimates of (1) on overall LOS

	(1) Coef. S.E.	(2) Coef. S.E.	(3) Coef. S.E.	(4) Coef. S.E.	(5) Coef. S.E.
Post 2005	-1.650*** (0.230)	-0.152 (0.118)	-0.150 (0.119)	-0.160 (0.118)	-0.193 (0.120)
Post 2007	-0.406*** (0.062)	-0.432*** (0.055)	-0.434*** (0.055)	-0.429*** (0.055)	-0.445*** (0.055)
Public Comp	-	-	-	-	-
Private Comp	-	-	-	-	-
Post 2005 * Pub. Comp	-1.115*** (0.250)	-0.395*** (0.093)	-0.387*** (0.096)	-0.389*** (0.093)	-0.384*** (0.094)
Post 2007 * Priv. Comp	0.123* (0.052)	0.154*** (0.043)	0.158*** (0.044)	0.154*** (0.043)	0.169*** (0.044)
Patient Char.	Yes	Yes	Yes	Yes	
Hospital F.E.	Yes	Yes	Yes	Yes	
Procedure F.E.	Yes	Yes	Yes	Yes	
Excluding London	Yes				
FT Status * Post 2005		0.021 (0.029)			
Teaching Indicator * Post 2005			-0.041 (0.055)		
Big Hospital Indicator * 2006				0.020 (0.029)	
Count of ISTCs * Post 2005					0.177* (0.078)
Public Comp Measure	Count within 333 population market	Count within 333 population market	Count within 333 population market	Count within 333 population market	Count within 333 population market
Private Comp Measure	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market
Obs	1653425	1882750	1882750	1882750	1882750
R-Squared	0.758	0.756	0.756	0.756	0.756

Notes: Dependent variable is patient's overall length of stay. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Least-squared estimates of (1) on pre- and post-surgery length of stay

	(1)		(2)		(3)		(4)	
	Pre-Surgery Coef. S.E.	**Post-Surgery Coef. S.E.**	**Pre-Surgery Coef. S.E.**	**Post-Surgery Coef. S.E.**	**Pre-Surgery Coef. S.E.**	**Post-Surgery Coef. S.E.**	**Pre-Surgery Coef. S.E.**	**Post-Surgery Coef. S.E.**
Post 2005	-0.045 (0.035)	-0.099 (0.097)	-0.098*** (0.027)	-0.652*** (0.082)	-0.128*** (0.010)	-0.466*** (0.024)	-0.217*** (0.021)	-0.731*** (0.059)
Post 2007	-0.112*** (0.017)	-0.317*** (0.046)	-0.147*** (0.019)	-0.317*** (0.055)	-0.109*** (0.010)	-0.218*** (0.023)	-0.103*** (0.009)	-0.245*** (0.022)
Public Comp	-	-	-	-	-	-	-	-
Private Comp	-	-	-	-	-	-	-	-
Post 2005 * Pub. Comp	-0.085** (0.028)	-0.311*** (0.077)	-0.024* (0.012)	-0.291* (0.140)	-0.004*** (0.001)	-0.003 (0.002)	-0.128*** (0.037)	-0.476*** (0.107)
Post 2007 * Priv. Comp	0.020 (0.013)	0.134*** (0.037)	0.027*** (0.007)	0.070** (0.024)	0.003** (0.001)	0.009*** (0.002)	0.002* (0.001)	0.014*** (0.002)
Patient Char.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hospital F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Procedure F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Public Comp Measure	Count within 333k pop market	Count within 333k pop market	Count within 666k pop market	Count within 666k pop market	Count within 20km Fixed	Count within 20km Fixed	Predicted Flow HHI	Predicted Flow HHI
Private Comp Measure	Count within 333k pop market	Count within 333k pop market	Count within 666k pop market	Count within 666k pop market	Count within 20km Fixed	Count within 20km Fixed	Count within 20km Fixed	Count within 20km Fixed
Obs	1882750	1882750	1882750	1882750	1882750	1882750	1882750	1882750
R-Squared	0.340	0.747	0.340	0.747	0.340	0.747	0.340	0.747

Notes: Dependent variables are patients' pre-surgery and post-surgery length of stay. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Tests of the robustness of least squared estimates of (1) on pre-surgery LOS

	(1) Coef. S.E.	(2) Coef. S.E.	(3) Coef. S.E.	(4) Coef. S.E.	(5) Coef. S.E.
Post 2005	-0.049 (0.037)	-0.039 (0.035)	-0.050 (0.035)	-0.051 (0.035)	-0.058 (0.035)
Post 2007	-0.113*** (0.019)	-0.109*** (0.017)	-0.117*** (0.017)	-0.112*** (0.017)	-0.116*** (0.017)
Public Comp	-	-	-	-	-
Private Comp	-	-	-	-	-
Post 2005 * Pub. Comp	-0.081** (0.030)	-0.086** (0.028)	-0.077** (0.029)	-0.083** (0.028)	-0.082** (0.028)
Post 2007 * Privy. Comp	0.018 (0.015)	0.019 (0.013)	0.024+ (0.013)	0.020 (0.013)	0.023+ (0.013)
Patient Char.	Yes	Yes	Yes	Yes	Yes
Hospital F.E.	Yes	Yes	Yes	Yes	Yes
Procedure F.E.	Yes	Yes	Yes	Yes	Yes
Excluding London	Yes				
FT Status * Post 2005		-0.016+ (0.009)			
Teaching Indicator * Post 2005			-0.039* (0.016)		
Big Hospital Indicator * 2006				0.008 (0.009)	
Count of ISTCs * Post 2005					0.046+ (0.024)
Public Comp Measure	Count within 333 population market	Count within 333 population market	Count within 333 population market	Count within 333 population market	Count within 333 population market
Private Comp Measure	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market
Obs	1653425	1882750	1882750	1882750	1882750
R-Squared	0.353	0.340	0.340	0.340	0.340

Notes: Dependent variable is patient's overall length of stay. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Tests of the robustness of least squared estimates of (1) on post-surgery LOS

	(1) Coef. S.E.	(2) Coef. S.E.	(3) Coef. S.E.	(4) Coef. S.E.	(5) Coef. S.E.
Post 2005	-1.650*** (0.230)	-0.113 (0.097)	-0.100 (0.098)	-0.109 (0.098)	-0.136 (0.100)
Post 2007	-0.406*** (0.062)	-0.323*** (0.046)	-0.317*** (0.047)	-0.317*** (0.046)	-0.329*** (0.047)
Public Comp	-	-	-	-	-
Private Comp	-	-	-	-	-
Post 2005 * Pub. Comp	-1.115*** (0.250)	-0.309*** (0.077)	-0.310*** (0.079)	-0.307*** (0.077)	-0.302*** (0.077)
Post 2007 * Priv. Comp	0.123* (0.052)	0.136*** (0.037)	0.134*** (0.037)	0.134*** (0.037)	0.145*** (0.038)
Patient Char.	Yes	Yes	Yes	Yes	Yes
Hospital F.E.	Yes	Yes	Yes	Yes	Yes
Procedure F.E.	Yes	Yes	Yes	Yes	Yes
Excluding London	Yes				
FT Status * Post 2005		0.037 (0.023)			
Teaching Indicator * Post 2005			-0.002 (0.043)		
Big Hospital Indicator * 2006				0.013 (0.024)	
Count of ISTCs * Post 2005					0.131* (0.065)
Public Comp Measure	Count within 333 population market	Count within 333 population market	Count within 333 population market	Count within 333 population market	Count within 333 population market
Private Comp Measure	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market	Count beds within 333 population market
Obs	1653425	1882750	1882750	1882750	1882750
R-Squared	0.758	0.747	0.747	0.747	0.747

Notes: Dependent variable is patient's overall length of stay. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Least squared estimates of (1) on whether or not patients had surgery on the day that they were admitted to the hospital

	(1) Coef. S.E.	(2) Coef. S.E.	(3) Coef. S.E.	(4) Coef. S.E.
Post 2005	0.048	0.097***	0.120***	0.196***
	(0.033)	(0.026)	(0.009)	(0.020)
Post 2007	0.106***	0.142***	0.105***	0.098***
	(0.016)	(0.018)	(0.010)	(0.009)
Public Comp	-	-	-	-
Private Comp	-	-	-	-
Post 2005 * Pub. Comp	0.076**	0.020+	0.004**	0.106**
	(0.027)	(0.011)	(0.001)	(0.035)
Post 2007 * Priv. Comp	-0.017	-0.026***	-0.003**	-0.002*
	(0.012)	(0.007)	(0.001)	(0.001)
Patient Char.	Yes	Yes	Yes	Yes
Hospital F.E.	Yes	Yes	Yes	Yes
Procedure F.E.	Yes	Yes	Yes	Yes
Public Comp Measure	Count within 333k pop market	Count within 666k pop market	Count within 20km Fixed	Predicted Flow HHI
Private Comp Measure	Count within 333k pop market	Count within 666k pop market	Count within 20km Fixed	Count within 20km Fixed
Obs	1882750	1882750	1882750	1882750
R-Squared	0.373	0.373	0.373	0.373

Notes: Dependent variable is whether or not patients had surgery on the day that they were admitted for care. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Least squared estimates of (1) on the age of patients at incumbent public hospitals

	(1) **Coef.** **S.E.**	(2) **Coef.** **S.E.**	(3) **Coef.** **S.E.**	(4) **Coef.** **S.E.**
Post 2005	0.972*** (0.192)	0.957*** (0.159)	0.746*** (0.059)	0.653*** (0.121)
Post 2007	0.011 (0.101)	-0.142 (0.110)	-0.015 (0.059)	-0.005 (0.055)
Public Comp	-	-	-	-
Private Comp	-	-	-	-
Post 2005 * Pub. Comp	-0.207 (0.151)	-0.109 (0.069)	-0.005 (0.007)	-0.124 (0.209)
Post 2007 * Priv. Comp	0.051 (0.085)	0.099* (0.048)	0.015* (0.007)	0.013* (0.006)
Patient Char.	Yes (excluding age)	Yes (excluding age)	Yes (excluding age)	Yes (excluding age)
Hospital F.E.	Yes	Yes	Yes	Yes
Procedure F.E.	Yes	Yes	Yes	Yes
Public Comp Measure	Count within 333k pop market	Count within 666k pop market	Count within 20km Fixed	Predicted Flow HHI
Private Comp Measure	Count within 333k pop market	Count within 666k pop market	Count within 20km Fixed	Count within 20km Fixed
Obs	1882750	1882750	1882750	1882750
R-Squared	0.339	0.339	0.339	0.339

Notes: Dependent variable is the age of patients at public facilities. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Least squared estimates of (1) on the social-economic status of patients at incumbent public hospitals

	(1) Coef. S.E.	(2) Coef. S.E.	(3) Coef. S.E.	(4) Coef. S.E.
Post 2005	0.010*** (0.002)	0.009*** (0.001)	0.010*** (0.000)	0.015*** (0.001)
Post 2007	0.001 (0.001)	-0.001 (0.001)	0.003*** (0.000)	0.002** (0.000)
Public Comp	-	-	-	-
Private Comp	-	-	-	-
Post 2005 * Pub. Comp	0.002 (0.001)	0.002** (0.001)	0.0005*** (0.00005)	0.005** (0.002)
Post 2007 * Priv. Comp	0.002*** (0.001)	0.002*** (0.000)	0.0002** (0.00006)	0.0005*** (0.00006)
Patient Char.	Yes (excluding age)	Yes (excluding age)	Yes (excluding age)	Yes (excluding age)
Hospital F.E.	Yes	Yes	Yes	Yes
Procedure F.E.	Yes	Yes	Yes	Yes
Public Comp Measure	Count within 333k pop market	Count within 666k pop market	Count within 20km Fixed	Predicted Flow HHI
Private Comp Measure	Count within 333k pop market	Count within 666k pop market	Count within 20km Fixed	Count within 20km Fixed
Obs	1878273	1878273	1878273	1878273
R-Squared	0.427	0.427	0.427	0.428

Notes: Dependent variable is the socio-economic status of patients at public facilities measured using the income vector of the 2004 Index of Multiple Deprivations. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 1: Calculated Predicted Patient Flow HHIs

Our HHIs based on predicted patient flows were calculated as follows. First, take patient *i* who was registered at GP *k* and received a hip replacement at hospital *j* in 2002. We assumed that each hospital located within 100km of GP *k* was a potential option if it performed at least 20 hip replacements per year. Then, we modeled the patient *i*'s choice as a function of *i's* characteristics, *i*'s GP *k*'s characteristics, the characteristics of the hospitals within 100km of *k* and the differential distances from *k* to those hospitals.

To do this, we aggregated our data up to the GP level. Here, we computed the average characteristics of all patients referred from *k* for a hip replacement in 2002. At the GP level, we know the actual frequency that *k* refers patients to hospital *j*. Thus, we generated a Poisson regression where the dependent variable was the count of patients referred by GP *k* to hospital *j*, controlling for the average socio-economic status for hip replacement patients in GP practice *k*, *k's* annual number of hip replacement referrals, the average age of hip replacement patients at *k*, the average level of morbidity of hip replacement patients *k*, *and* the gender distribution at *k*. Here, socio-economic status was measured using the income vector of the 2004 index of multiple deprivations and morbidity was measured using the Charlson index of comorbidity.

Consistent with previous work that predicted patient flows, we do not include either patient characteristics or hospital characteristics on their own. Instead, they are all entered interacted with the distance from GP to the nearest hospitals within 100km. In addition, similar to Kessler and McClellan (2000) and Gaynor et al. (2010), we did not include hospital fixed effects

The underlying Poisson regression we used was akin to the conditional logit used in Kessler and McClellan (2000) and generated predicted counts of the number of patients GP *k* would refer to hospital *j*. In our Poisson, we assumed that groups of individuals *i* represented by their GP *k*'s would gain indirect utility U^*_{kj}, from choosing hospital *j* based on the sum of a function *V(.)*, defined by interactions of the relative distances of the potential choices and hospital characteristics demographic characteristics and GP referral patterns, and a factor, ε_{kj} representing unobservable heterogeneity of individuals, GPs and hospitals as it influence choice.

Thus $U^*_{kj} = V(.)$

Here, McFadden (1973) shows that through specifying the distribution of all residual factors, ε_{kj}, and assuming these to be independently and identically distributed according to the extreme value distribution, the probability of patient *i* registered at GP *k* choosing hospital *j*, π_{kj}, can be expressed as a function of all relevant characteristics and parameters estimates, constrained to be the same for all alternatives associated with these characteristics through application of a (conditional) logistic function such that:

$$\Pi_{kj} = \Pr(U_{kj} = 1) = \frac{e^{(V_{kj})}}{\sum_{l \in J} e^{(V_{kl})}}$$

The parameter estimates can be returned through maximizing the log-likelihood function:

$$LogL = \sum_{k=1}^{N} \sum_{j=1}^{J} \log(\Pi_{kj})$$

i.e. through estimation of the conditional logit model. Again, to make the computations easier, we built off of the main findings from Guimaraes et al. (2003) who show that because of the equivalent relationship between likelihood function of the conditional logit and the Poisson regression, we can use the Poisson regression model to return the same parameter estimates.

Ultimately, our Poisson model explains approximately 50% of the variation in GP referrals and can be written in log form as:

$$\ln C_{kj} = \alpha + \sum_{kj} \beta X + \varepsilon_{kj}$$

where C_{kj} are the counts of individuals *i* registered at GP *k* who are referred for care at hospital *j*, and *X* is a matrix of independent variables that includes distance interacted with the type of hospital (e.g. whether FT or private), hospital activity levels, patient characteristics averaged across GP practices (gender, socio-economic status and level of co-morbidities), and the annual number of GP referrals per *k*.

Following Kessler and McClellan (2000), we used these predicted counts ($count_{kj}$) to generate market shares, denoted α_{kj}, for all hospitals $j = 1 \ldots, j$, located within 100km of *k:*

$$\hat{\alpha}_{kj} = \frac{\hat{count}_{kj}}{\sum_{j=1}^{J} \hat{count}_{kj}}.$$

We then used these predicted market shares generated from the predicted count of patients referred from *k* to *j* to create GP-level HHIs. These GP-level HHIs were the sum of the squares of the predicted market shares of providers within 100km of *k:*

$$HHI_k = \sum_{j=1}^{J} \hat{\alpha}_{kj}^{2}.$$

This measure would be similar to our fixed radius HHIs centered on GP practices, except that the market shares used to create the HHI_k would be based on predicted patient flows. Consistent with our other measures, we aggregated this measure up to hospital level based on a weighted average of all GP measures located within 60km of hospital *j*, where the weight is one divided by the distance from *j* to *k.*

Appendix 2: Least squared estimates of competition on pre-surgery, post-surgery and overall LOS where the public and private competition measures are interacted with year dummies.

	(1) Pre-Surgery LOS Coef. S.E.	(2) Post-Surgery LOS Coef. S.E.	(3) Overall LOS Coef. S.E.
2003 post * Comp public	-0.026	0.029	0.002
	(0.058)	(0.132)	(0.150)
2004 post * Comp public	-0.034	0.061	0.027
	(0.053)	(0.127)	(0.145)
2005 post * Comp public	-0.058	0.139	0.082
	(0.051)	(0.125)	(0.145)
2006 * Comp public	-0.088+	0.143	0.055
	(0.051)	(0.128)	(0.147)
2007 post * Comp public	-0.117*	-0.035	-0.152
	(0.058)	(0.131)	(0.155)
2008 post * Comp public	-0.141*	-0.278*	-0.419**
	(0.057)	(0.135)	(0.159)
2009 * Comp public	-0.142**	-0.284*	-0.425**
	(0.053)	(0.140)	(0.161)
2010 post * Comp public	-0.116*	-0.372*	-0.488**
	(0.056)	(0.148)	(0.173)
2003 post * Comp private	-0.007	0.044	0.036
	(0.026)	(0.083)	(0.092)
2004 post * Comp private	-0.019	0.008	-0.011
	(0.023)	(0.073)	(0.081)
2005 post * Comp private	-0.044+	-0.010	-0.054
	(0.023)	(0.071)	(0.079)
2006 post * Comp private	-0.054*	-0.018	-0.072
	(0.025)	(0.067)	(0.078)
2007 post * Comp private	-0.050*	0.054	0.004
	(0.025)	(0.071)	(0.083)
2008 post * Comp private	-0.025	0.111	0.086
	(0.025)	(0.073)	(0.082)
2009 post * Comp private	-0.006	0.156*	0.150+
	(0.024)	(0.076)	(0.084)
2010 post * Comp private	-0.002	0.198*	0.195*
	(0.025)	(0.078)	(0.088)
Year Post Dummies	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes
Patient Controls	Yes	Yes	Yes
Public Comp Measure	Count within 333k pop market	Count within 333k pop market	Count within 333k pop market
Private Comp Measure	Count within 333k pop market	Count within 333k pop market	Count within 333k pop market
Obs	1882750	1882750	1882750
R2	0.340	0.752	0.743

Notes: Dependent variable is whether or not patients had surgery on the day that they were admitted for care. Patient characteristics include five-year age band dummies, dummies for the quintile of the income vector of the 2004 index of multiple deprivations and an indicator for patient gender. The estimates also include day of week and month time dummies. Standard errors are clustered around hospitals within years. + $p < 0.10$ *, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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