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New Joints: Private providers and rising demand in the English National Health Service

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Abstract

Reforms to public services have extended consumer choice by allowing for the entry of private providers. The aim is to generate competitive pressure to improve quality when consumers choose between providers. However, for many services new entrants could also affect whether a consumer demands the service at all. We explore this issue by considering how demand for elective surgery responds following the entry of private providers into the market for publicly funded health care in England. For elective hip replacements, we find that demand shifts account for at least 7% of public procedures conducted by private hospitals. These results are robust to instrumenting for location using the presence of existing healthcare facilities. Exploiting rarely used clinical audit data, we show that these additional procedures are not substitutions from privately funded procedures, and represent new surgeries, at least within a given year. The increase in volumes resulting from a demand shift improve consumer welfare, but impose fiscal costs, and do not contribute the original aim of the reforms to stimulate competition.

Keywords: public service choice; healthcare demand; geographic variation
JEL Classification: I11; I18; L33

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1 Introduction

Governments in many countries around the world have sought to increase the role of choice in public services such as health and education [*Besley and Ghatak*, 2003; *Musset et al.*, 2012; *Vrangbaek et al.*, 2012]. The aim is typically to increase competition between providers, generating incentives to improve quality [*Hoxby*, 2003; *Gaynor*, 2006]. One type of reform used to enhance choice is allowing the entry of private or third sector providers, expanding the options available to consumers. The most prominent reforms of this type are in education, through Charter schools [*Angrist et al.*, 2013; *Imberman*, 2011; *Ladd*, 2002], and private school vouchers [*Hsieh and Urquiola*, 2006; *Neal*, 2002; *Nechyba*, 2000]. In the context of schooling, where decisions are for the most part compulsory, consumers can only respond to the new options available by changing provider. This paper considers how consumer demand responds when additional providers are introduced in an environment where there is an outside option.

We consider the case of elective surgery, where the decisions of whether and when to have surgery often depend on the preferences of patients and doctors in addition to clinical need [*Fisher et al.*, 2003a,b; *Wennberg*, 2011]. Reforms that increase the choices available to patients along margins that they value - such as distance or quality - may therefore affect not just *where* patients decide to have a procedure, but *whether* they have a procedure at all[1]. It is this second margin, whether new entrants increase the level of demand, that we will consider. This is important as reforms that result in additional demand for surgery (or the use of any other public service) will have a greater impact on the public finances, have additional effects on consumer welfare, and dampen the impact of competition, compared to reforms where demand remains fixed[2].

We exploit a set of reforms to the National Health Service (NHS) in England in the mid 2000s, which enabled privately funded hospitals to treat publicly funded elective patients. Our analysis focuses on elective hip replacements, where the reforms increased the set of hospitals available to elective patients by more than half, from 150 in 2002/03 to 257 in 2010/11[3]. Over the same period, the annual number of hip replacements by more than 60%, with half of these additional surgeries provided by privately-owned hospitals. Much of this rise is accounted for by the direct and intended increase in aggregate supply. However, in contrast to expanding capacity in existing

[1]See *Ho* [2006]; *Beckert et al.* [2012]; *Gaynor et al.* [2016]; *Capps et al.* [2003] for discrete choice models of hospital choice and *Arcidiacono* [2005] and *Keane and Wolpin* [2001] for models of tertiary education.

[2]In this paper, we will use patient demand as a short hand for the combination of patient and GP demand. We do not attempt to separate the two. However, referring GPs do not have any direct financial incentive to refer or not refer patients in England. We therefore assume that GPs are acting as an agent in the best interest of the patient.

[3]Throughout the paper, "NHS-funded" and "publicly-funded" hip replacements will be used synonymously. We focus on hip replacements as: (i) the procedure is performed in large volumes across most NHS hospitals in England; (ii) privately-owned hospitals had a substantial market share of the NHS funded market by 2010/11, accounting for almost a fifth of procedures, and; (iii) there is information on the private pay sector via a clinical audit of joint replacements [*Kelly and Tetlow*, 2012]. We include only elective hip replacement patients. We exclude patients admitted in an emergency, as these patients have no choice over whether they receive treatment.

hospitals, additional hospitals may also change the options available on dimensions that matter to patients, including distance and potentially quality. In this paper, we exploit variation in the introduction of providers over time and space to examine whether the entry of private providers also created additional (and unintended) increases in hip replacement volumes through an outwards shift in patient demand[4].

The primary data source for NHS-funded procedures comes from the inpatient Hospital Episode Statistics. These administrative data document every admission to an NHS hospital, and admissions to privately-owned hospitals funded by the NHS. As we cannot observe potential patients that did not have a hip replacement in these administrative data, we aggregate numbers of NHS-funded hip replacements to the Middle Layer Super Output Area (MSOAs) level (similar to census tracts)[5]. We then construct a (balanced) panel data set of the number of procedures in all 6,781 MSOAs in England, for each financial year from April 2002 through March 2011. This enables us to examine changes in the levels or rates of procedures across the country, even though we cannot observe the decisions of individual patients. To exploit variation in the introduction of privately owned hospitals, we geocode each MSOA with straight-line distances to the nearest NHS and privately owned hospital in each year and augment with a series of MSOA characteristics, including demographics, other measures of population health created using the Hospital Episode Statistics, and economic activity.

We identify shifts in demand using changes in procedure numbers following the introduction or new availability of a privately owned hospital. To separate changes in quantities driven by shifts in demand from those caused by an increase in supply, we exploit variation in the relative distance to the nearest available privately owned hospital over time within regions with common supply, in terms of the funding available, the sets of hospitals and provider incentives[6]. Patients and their referring physicians are expected to have preferences for shorter distances, which reduce travel costs[7], but proximity may also bring increased salience when referral decisions are made. Supply, by contrast, is common across much broader geographical regions, which we define as the 152 administrative areas tasked with funding health care for their residents during this period.

To identify impacts on demand, our baseline results use the enhanced panel data set to estimate fixed effects models, which controls for time trends within the wider administrative area. We address concerns about endogenous placement of privately owned hospitals within administrative areas, by instrumenting with the presence of existing health care sites. We show that these in-

[4]In this context, demand for procedures is downwards sloping in waiting times. A shift in demand therefore indicates an increase in the quantity of procedures demanded with waiting times held constant.

[5]MSOAs are small geographic areas (with an average population of 7,200) used for census and other statistical aggregation. They have no administrative jurisdiction.

[6]What this reform does not allow us to identify is whether the type of provider matters, as there are very limited changes in the number of public hospitals.

[7]Discrete models of hospital choice all show a strong preference for shorter travel distances [*Beckert et al.*, 2012; *Gaynor et al.*, 2016; *Kessler and McClellan*, 2000; *Ho*, 2006]. For example, *Ho* [2006] finds that an additional mile reduces the probability that the patient will choose the hospital by 21%.

struments are extremely strong, as most of the hospitals that began treating NHS patients were existing private hospitals, and we provide evidence to support the exclusion restriction that the presence of existing hospital sites would not otherwise have affected the change in procedure numbers over this period. Extended analysis uses rarely available data on the private-pay sector from a clinical audit to provide a further test of our exclusion restriction and to examine whether the reforms led some patients who would have paid for their procedure through self-pay or private insurance to substitute towards NHS funded care. Our principal results are three-fold.

First, when privately owned hospitals become the nearest provider of NHS-funded hip replacements, our most conservative estimate suggests that MSOA annual volumes of elective hip replacements increase by 0.5 procedures per year. This compares to a pre-reform average of 5.8 hip replacements in 2002/03, and accounts for approximately 20% of the average rise of 2.6 procedures between 2002/3 and 2010/11. Using these estimates, we calculate that in 2010/11 shifts in demand as a response to availability of privately owned hospitals generated an additional 810 procedures, or 6.9% of the total number of procedures conducted by privately owned hospital for the NHS. These additional procedures cost the NHS around £4 million (USD 5.2 million). These additional procedures did not enhance competition for public providers as consumers chose between the privately owned provider and no procedure. Our results are robust to alternative definitions of distance and the relevant privately owned hospitals, and remain when we instrument location with pre-existing medical facilities. These results are consistent with both a high value placed on distance by patients, or through higher levels of salience for both patients and referring primary care physicians when additional hospitals become available nearby.

Second, using clinical audit data, we again find the same pattern of higher demand estimated using NHS administrative records, but there is no evidence that these additional procedures represent substitutions from the private *pay* sector. This supports our exclusion restriction and implies that the extra procedures are 'new', at least within a given financial year. The absence of substitution is consistent with a 2014 UK Competition and Markets Authority Report, which used survey evidence to conclude that the NHS-funded and privately-funded healthcare markets were separate and imposed limited constraints on one another [*Competition and Markets Authority*, 2014].

Finally, we find that when privately owned hospitals begin treating publicly funded patients, local NHS hospitals show a fall in waiting times but no change in elective hip replacement volumes. The rationing of treatment via waiting lists combined with relatively plentiful public funding, allowed public hospitals to replace patients who substituted towards privately owned hospitals with patients from further down the waiting lists. This suggests that the additional hip replacements we estimate represent a permanent increase in procedures and associated costs for the cohorts affected, irrespective of whether the patient would otherwise have died before having the procedure, or the procedure was brought forward allowing another patient to take their place. The additional procedures therefore improved consumer welfare, but also generated increased costs for the publicly funded NHS.

Together our results make three main contributions. First, we contribute to literature that examines choice of provider in healthcare [*Beckert et al.*, 2012; *Gaynor et al.*, 2016; *Ho*, 2006] and other services such as education [*Arcidiacono*, 2005; *Keane and Wolpin*, 2001]. We show that in situations where there is an outside option, changing hospital choice sets or the characteristics of hospitals within existing choice sets, can affect decisions on the extensive margin. The set of decision makers is not necessary exogenous. Relatedly, we contribute to the literature on expanding choice in the public sector, which has typically focused on the impacts on provider quality or consumer outcomes.

Second, our results contribute to the growing literature on the geographic variation in healthcare utilization, by providing both some context and one potential contributing mechanism. In terms of context, we provide evidence of geographic variation in England, where the types of physician incentives discussed as possible causes in the US context are absent [*Chandra et al.*, 2011; *Finkelstein et al.*, 2016; *Skinner*, 2011]. In terms of mechanisms, we show that patients respond to the characteristics and organization of the hospitals available. A patient that moves to an area with a denser network of hospitals may have higher healthcare use, because it is easier or quicker to access healthcare. Opening a new hospital could, to some extent, 'create' new demand, particularly in the grey area of medicine where there are less established protocols[8].

Finally, although we exploit a policy change designed to increase choice, our results have wider applicability to changes in hospital availability more generally, either through the ongoing process of hospital consolidation [*Barro and Cutler*, 2000; *Gaynor and Town*, 2012; *Gaynor*, 2011] or reforms that alter patient access to hospitals, such as managed care [*Glied*, 2000; *Ho*, 2006] or patient choice reforms [*Cooper et al.*, 2011; *Gaynor et al.*, 2016]. These literatures have tended to focus on the supply side, and the resulting impacts on prices, productivity and quality. We show that there may also be demand-side responses, which have important implications for both patient welfare and hospital competition.

The rest of the paper is organized as follows. Section 2 details the institutional background and the reforms. Section 3 describes our identification strategy, data and empirical method. Section 4 presents our baseline results and robustness tests using NHS administrative data. Section 5 uses clinical audit data to consider the extent of substitution between privately and publicly funded procedures. Section 6 provides some evidence on the impact on NHS hospitals. Section 7 concludes.

[8] An earlier literature on supplier induced demand sought to explain the positive association between availability and use through physicians exploiting their agency to 'induce' demand [*Fuchs*, 1978; *Auster and Oaxaca*, 1981; *Gruber and Owings*, 1996]. The difficulty is in identifying whether observed quantities are high due to high supply or high demand. Our results suggest that patient demand does respond to exogenous shifts in supply. While our identification strategy focuses on distance, it seems plausible that patients and referring physicians would also respond to improvements in quality.

2 Background

2.1 Institutional Background and Policy Reforms

The majority of health care in England is funded by the state through general taxation, and provided through the National Health Service (NHS) free at the point of use. Patients access elective hospital services, such as hip replacements, through a referral from their primary care doctor or General Practitioner (GP). There are no self-referrals. Secondary or hospital care, including both outpatient consultations and inpatient treatment, has historically been delivered by state owned and run NHS Acute Trusts, or hospitals, and is rationed through waiting times[9]. These hospitals receive per patient payments for the treatments provided, where payments for each type of treatment are set at a national level[10]. There is a small private pay sector, which accounted for a fifth of hip replacements in 2002 [*Arora et al.*, 2013].

This paper focuses on a set of reforms that opened up the market for NHS-funded elective care to non-NHS providers. The NHS had purchased small volumes of care from the private or independent sector on an ad hoc basis for many years. However, reforms introduced between 2003 and 2008 formalized and greatly increased the ability of non-NHS hospitals to compete with NHS hospitals for patients, and the opportunities for NHS-funded patients to access treatment at non-NHS hospitals. We will refer to these reforms as the "Independent Sector Provider" reforms and the non-NHS hospitals as "Independent Sector Providers" (ISPs). ISPs providing hip replacements were exclusively privately owned and run hospitals.

The reforms were introduced in two waves, which correspond to the changing focus of NHS priorities during the 2000s. The first wave the ISP reforms commenced in 2003, with the principal aims of reducing waiting times and addressing capacity constraints. This reflected the focus of NHS policy in the 2000s, which aimed to reduce the very long waiting times within the NHS, initially through strict waiting time targets backed with increases in funding [11]. Figure 1 shows the change in mean and median waiting times over the 2000s, and shows sharp decreases as targets were imposed and then tightened. The new ISPs introduced in this period were designed to concentrate on routine patients, allowing the NHS to focus on emergency care and the more complex cases [*Naylor and Gregory*, 2009]. Most ISPs that opened at this stage were privately owned but treated

[9] An NHS Acute Trust may be comprised of a single hospital or multiple hospitals within the same geographic area. For ease of expression we will refer to these NHS Acute Trusts as hospitals.

[10] Hospital care is grouped into Healthcare Resource Groups (HRGs), which are similar to Diagnostic Resource Groups in the US. Prices or Tariffs are then set at a national level based on the average cost of providing the associated care. Small adjustments are made for unavoidable local differences in costs and length of stay.

[11] The first waiting times target was introduced in April 2001, with a maximum wait of 18 months between the decision to admit and inpatient admission. The target was reduced by three months each year. In December 2008 a new referral to treatment (RTT) target was introduced, with a maximum wait of 18 weeks between GP referral and inpatient admission. See *Propper et al.* [2010] for discussion and evidence on the waiting time targets that were implemented from 2000 onwards.

only NHS patients[12].

The second wave of the ISP reforms was launched in 2006, with the expanded objectives of increasing competition for NHS providers and fostering innovation [*Naylor and Gregory*, 2009]. At this point, the main focus of NHS policy moved away from the now much lower waiting times and towards introducing consumer choice and competition between providers. The patient choice reforms of 2006 established a requirement for GPs to offer patients a choice of hospital when referring patients for almost all elective care[13]. The second wave of ISPs then offered patients a wider choice set of hospitals for a number of elective treatments. The aim was that this would generate more competition for NHS hospitals and provide an illustration of the potential for efficiency gains. From 2006 onwards, most of the new ISPs were existing privately owned hospitals that treated privately and NHS funded patients alongside one another[14]. This second reform has more in common with private school vouchers that have operated in the US, Chile and elsewhere [*Hsieh and Urquiola*, 2006; *Neal*, 2002; *Nechyba*, 2000]. By 2010/11, two thirds of patients treated by ISPs were treated by this type of ISP.

The "Independent Sector Reforms" have received far less attention from the economics of health care literature than the concurrent patient choice reforms. Almost all existing work work focuses the first wave of the reform, and concentrates on case mix. *Chard et al.* [2011], *Bardsley and Dixon* [2011] and *Audit Commission* [2008], for example, find that patients treated by the first wave of ISPs are healthier and wealthier than those treated by NHS hospitals. Similarly, *Cooper et al.* [2015] find that the introduction of the first wave of ISPs led to costlier case-mix for nearby NHS hospitals. Some of this sorting of less complex patients towards ISPs is a consequence of government regulations on which patients were eligible, as ISPs do not have intensive care facilities available. However, there remains a debate as to the extent that ISPs further adjusted their eligibility criteria to 'cherry-pick' the least costly patients [*Naylor and Gregory*, 2009; *Audit Commission*, 2008; *Cooper et al.*, 2015].

The growth in the role of ISPs in the market for elective hip replacements is illustrated by Figure 2, which shows the number of annual procedures by provider type. There are three points of note. First, total elective hip replacements increased by 61% over the period. This reflects a general pattern in NHS elective care in the 2000s, irrespective of whether ISPs entered the market for a particular surgery. A small share of increase (around a fifth for elective hip replacements) is explained by demographic change, the remainder and real driving forces were a combination of increased funding and waiting time targets [*Kelly and Tetlow*, 2012; *Arora et al.*, 2013]. Second,

[12] These providers were known as Independent Sector Treatment Centres (ISTCs)

[13] The limit on the number of hospitals was then removed in 2008. This replaced a system where patients could state preferences but GPs were under no obligation to actively offer their patients a choice. Henceforth, we will refer to these reforms as the "patient choice reforms". These reforms were motivated by both the belief that patients valued the choice over their care, and evidence that health care competition (when prices were fixed) could improve quality [*Gaynor*, 2006]

[14] To be clear, these hospitals were treating privately funded patients before the ISP reforms. The reforms added NHS-funded patients to their patient roll.

ISPs provided almost no NHS-funded hip replacements in 2002/03, but after 2007/08 their market share grew rapidly, reaching 18% in 2010/11. Third, the number of procedures conducted by NHS hospitals increased between 2002/03 and 2007/08, but leveled off after ISPs began to grow.

Figure 3 plots the locations of ISPs conducting at least 20 hip replacements per year in 2006/07, 2008/09 and 2010/11[15]. The number of ISPs grew from just nine in 2006/07, to 54 in 2008/09 and 106 in 2010/11. The map illustrates that ISPs were spread across the whole country. There was very little change in the number of NHS hospitals, which remained at around 160 throughout the period. By 2010/11, the ISP reform had therefore increased the number of hospitals available to patients by two-thirds. However, the greater volume of procedures conducted by each NHS hospital meant that NHS hospitals still delivered over 80% of all NHS-funded hip replacements by the end of the period[16].

2.2 The potential impact of ISPs on the market for hip replacements

Figure 4 provides a stylized example, which can be used to explain the change in the size and composition of the market for elective hip replacements observed in Figure 2. The left hand panel shows the market for NHS funded hip replacements provided by NHS hospitals, the only providers of NHS-funded hip replacements before the ISP reforms. Demand is downward sloping in waiting times. Supply is upward sloping until a certain level of procedures, but then becomes perfectly inelastic once hospitals are constrained by numbers of staff and beds. Assume that in 2001, when policies were first introduced to cut waiting times and increase health care provision, supply stood at S^{01}_{NHS}, and demand at D_{NHS}, giving an equilibrium quantity of $0P_A$ with a waiting time of W^{01}. Following the introduction of strict waiting time targets and additional funding for staff and beds, supply shifted out from S^{01}_{NHS} to S_{NHS}. Quantity rose from $0P_A$ to $0P_B$, while waiting times fell from W^{01} to W.

The introduction of ISPs generated a second segment to the market, displayed in the right hand panel. We assume in this market that supply is upward sloping along its whole length. The principal objectives of the ISPs reforms were to cut waiting times and increase competition for NHS hospitals. For both these goals, the implied "supply mechanism" was that some patients would switch from NHS hospitals to ISPs, shifting demand for NHS hospitals from D_{NHS} to D'_{NHS}[17]. Waiting times fall from W to W', with the impact on quantity depending on whether the equilibrium moves to the upward sloping portion of the demand curve. In this example quantity

[15]We restrict our attention to ISPs conducting at least 20 hip replacements to avoid potential issues of disclosivity of plotting ISPs that perform more than a lower minimal threshold. Furthermore, we argue that ISPs conducting a very small number of hip replacements may not be available in the choice sets of most patients. Reducing the minimum threshold from 20 to 5 procedures increases the number of ISPs by 22%, but these smaller sites accounted for just 2.7% of ISP patients in 2010/11.

[16]In 2010/11, ISPs performed an average of 90 hip replacements per hospital, compared to over 300 per NHS hospital.

[17]We assume for simplicity that the supply curve is unaffected. This is also consistent with the pattern in Figure 2, as total numbers of hip replacements conducted by NHS hospitals leveled off after ISPs were introduced.

remains P_B. Under the assumption that ISPs only shift patients away from NHS hospitals, the sum of the post-reform demand for ISPs (D^1_{ISP}) and NHS hospitals ($D^{'}_{NHS}$) is equal to the pre-reform demand (D_{NHS}). The total number of NHS hip replacements is equal to $0P_B$ hip replacements conducted by NHS hospitals plus $0I_A$ delivered by ISPs. Total quantity has risen by $0I_A$, as ISPs have increased supply and reduced waiting times, moving patients along the demand curve for elective hip replacements.

The impact of ISPs on supply benefits patients treated by NHS hospitals and by ISPs. Patients who would have otherwise have been treated experience lower waiting times, and additional patients receive a procedure they would not have had in that year. ISPs have receive a payment of I_A multiplied by the NHS tariff price (approximately £5,000 or USD 6,500). For NHS hospitals, the impact on volumes and revenue depends upon whether demand shifts to the upwards sloping portion of the supply curve[18].

In this paper we examine whether the increase in hip replacement is explained wholly by the "supply mechanism" described, with falls in waiting times leading to a rise in quantity and a movement along the market demand curve. In particular we ask whether the entry of ISPs also generates a shift in demand. The patient choice literature, at least within economics, typically treats the set of patients requiring treatment as fixed. However, many elective procedures can be delayed or avoided, through capacity constraints within a health system such as the NHS, lack of insurance coverage in the US, or patient preferences. Surveys of patients show a reluctance to undergo surgery, even when the procedure is clinically appropriate [*Hawker et al.*, 2001], and there are sizable variations in surgery rates by geography and socioeconomic group [*Fisher et al.*, 2003a,b]. When weighing up the costs and benefits of a procedure, patients will take waiting times (or price) into account, but there are many other factors that may be considered, including distance and the quality of clinical and hotel services. Patients will then choose to have the procedure if the expected utility from it exceeds the expected utility from the outside option.

Under the assumption that ISPs and NHS hospitals are perfect substitutes, demand for ISPs is represented by $D^1{}_{ISP}$, with $D^1{}_{ISP} + D^{'}{}_{NHS}$ equal to the pre-reform demand of D_{NHS}. However, when ISPs have characteristics that are preferred by some consumers, demand will shift to $D^2{}_{ISP}$, increasing hip replacements conducted by ISPs by an additional I_AI_B hip replacements. The aggregate number of hip replacements displayed in Figure 2 is $0I_B$, the sum of increase in hip replacements generated by the increase in supply ($0I_A$) and the impact of the shift in demand (I_AI_B).

Any additional hip replacements generated by a demand shift (I_AI_B) may come from two sources. First, substitutions from the private pay sector, which are explored in Section 5. Second, hip replacements that would not otherwise have taken place in that year. We will assume that any additional procedures are clinically appropriate in the same way that we assume that the additional

[18]There is potentially an increase in costs due to a change in case mix, countered by a potential improvement in efficiency generated by increased competition.

20,000 hip replacements conducted in 2010/11 relative to 2002/03 are clinically appropriate. The welfare and public finance implications of this type of expansion are discussed in Section 6.

In the context of the ISP reforms, the increase in hip replacements induced by the shift in demand ($I_A I_B$) is important because the additional procedures do not further either the waiting times or competition policy objectives: there is no reduction waiting times in NHS hospitals as D'_{NHS} is unaffected, and these are not patients that NHS hospitals could compete for, at least in a given time period. Welfare increases for patients $I_A I_B$ but falls for consumers $0 I_A$, as waiting times are slightly higher. ISPs receive a fixed payment for each hip replacement they conduct. Overall, the ISP program allowed revenues of private hospital groups to grow over the period between 2005 and 2012, even though revenue from privately funded patients remained flat in real terms [*Competition and Markets Authority*, 2014][19]. Whether the demand shift increases ISP profits depends upon whether $I_A I_B$ are new patients or substitution from the private pay sector, where the payment received is double that paid by the NHS [*Lunt et al.*, 2011; *Department of Health*, 2010].

While we consider the specific case of ISP reforms, the same potential mechanisms apply to other changes in patient and consumer choice sets. Over the past two decades, there have been substantial changes in the hospital choice sets faced by patients in many health care markets, with mergers and HMOs constraining choice sets, and policies such as the "patient choice reforms" and the introduction of Ambulatory Surgery Centres in the United States enabling or increasing choice. Understanding whether and how demand responds to changes in the size and characteristics of hospital choice sets has important implications for the costs faced by both public payers and insurance companies.

3 Identification, data and empirical method

3.1 Identification Strategy

The objective of this paper is to identify whether the introduction of ISPs led to a shift in demand for elective hip replacements, which explains part of the overall increase in hip replacements observed over the period. This differs from the existing literature on patient choice, which focuses on the hospitals that are chosen conditional on having a procedure, taking the set of patients as given. [*Beckert et al.*, 2012; *Gaynor et al.*, 2016; *Ho*, 2006]. Identifying demand responses at the extensive margin poses two challenges not present when considering the choice between hospitals. First, the administrative hospital data contain only those who chose to receive treatment. To address this, we aggregate hip replacements to the Medium Layer Super Output Area (MSOA)[20]. This allows

[19] By 2012, 27.3% of the revenue of private hospitals came from the NHS [*Laing & Buisson*, 2013]

[20] These MSOAs are statistical aggregation units, with no administrative jurisdiction. There are 6,781 MSOAs in England, with an average population of 7,500

us to consider changes in levels or rates across the country, even though we cannot observe the choices made by individual patients. Existing work in this area has typically been theoretical, which may in part reflect both difficulties in obtaining a sufficiently large and measurable change in competition, and the absence of data on patients who chose the outside option[21].

The second and more important challenge to identification is separating the impact of ISPs on demand from the effects on supply. As noted in Section 2.2, the total quantities observed in Figure 2 shows the combination of these two mechanisms. Our estimation strategy separates demand from supply by using variation in distance to hip replacement providers within areas that share a common supply side.

On the demand side, responses of patients and GPs may vary by distance through either a preference for shorter travel distances or higher salience at closer proximity[22]. The salience channel may be particularly important in this context, as GPs are gatekeepers to NHS hospital services. Even though there are no financial incentives to refer or not refer, GPs are aware that referrals create waiting time externalities for other patients who might be in greater need. ISPs treat less severe cases and have smaller waiting lists, so the expected externality is smaller.

On the supply side, during this period hospitals received payments from Primary Care Trusts, which received funding from central government for the treatments received by all patients living within their geographic area. Crucially, organizations have no incentives to fund patients living within their borders differentially. PCT areas were established in 2002, and consolidated in number in 2006 mostly by merging old PCT areas together. From 2006 onwards, England was divided into 152 PCT areas, covering an average of 330,000 people. Of these areas, 98 contained at least one MSOA where the nearest elective hip replacement provider was an ISP in 2010/11, and 107 contained at least one MSOA where the nearest elective hip replacement provider was an ISP at some point between 2002/03 and 2010/11. In other words, around two thirds of PCT areas contribute to our baseline estimation of the impacts of the introduction of ISPs on demand [23].

Figure 5 illustrates our baseline approach using an example from the Leicester City PCT area. Throughout the period, elective procedures for patients living within this area were all funded by the same PCT area administration. All hospitals were paid the same tariff or fee irrespective of where patients lived. In 2002/03, NHS-funded hip replacements were provided by the NHS hospital Leicester General Hospital. This hospital was the nearest NHS provider for residents within areas denoted by both the square and the circle. The ISP reforms meant that by 2010/11, patients

[21] *Brekke et al.* [2008], for example, present a theoretical model examining the relationship between competition and waiting times in a model with a competitive segment where patients choose between hospitals, and a monopoly segment where patients choose whether to receive treatment.

[22] Discrete choice models of hospital choice, in many countries and types of healthcare system, suggest that patients have a preference for shorter travel distances [*Beckert et al.*, 2012; *Gaynor et al.*, 2016; *Ho*, 2006]. Distance has a strong influence for other services, such as university [*Arcidiacono*, 2005; *Keane and Wolpin*, 2001] and school [*Burgess et al.*, 2015].

[23] Robustness tests will include models where all PCT areas contribute towards identification, by using measures of absolute and relative distance to ISPs.

could also receive NHS-funded treatment from Nuffield Health Leicester, which is a pre-existing privately owned hospital. For residents in the square area, the nearest provider changed to the ISP, whereas for residents of the circled area the nearest provider remained the NHS hospital. However, residents in both areas face identical choice sets and the same waiting time conditional on hospital choice. The only difference is in the relative distance to the new provider. A larger increase in hip replacements for residents in the square area can therefore only operate through the effect of relative distance on demand and not differences in supply[24].

3.2 Data and empirical method

Data on NHS-funded elective hip replacements comes from the inpatient Hospital Episode Statistics (HES) from April 2002 to March 2011. HES contain the records of all NHS-funded hospital care in England. This includes both care provided by NHS hospitals and care received by NHS-funded patients treated elsewhere[25]. The inpatient data contain information about the patient, including their age, sex, GP practice and local area, the admission type (emergency or elective) and dates, up to 20 diagnoses, and all procedures patients receive.[26]

To obtain a measure of how the rate of elective hip replacements varies across England and over time, we aggregate individual patient level records to the MSOA level for each financial year between April 2002 and March 2011[27]. There are a total of 6,781 MSOAs in England, with an average population of 7,200, giving a total sample of 61,029 MSOA/year observations. For each MSOA and year, we geocode to calculate the nearest NHS hospital and ISP that performed at least 20 hip operations[28].

In our baseline fixed effects specification, the number of (age and sex standardized) NHS-*funded* hip replacements (ISP plus NHS hospital) for residents of MSOA (small statistical area)

[24]There may be supply side factors that drive the number of hip replacements within the PCT area, such as the tastes of physicians, or some unobserved incentives offered by the PCT administration, but this should be constant across patients within the PCT. Extended results will define the relevant supply constraint as the nearest NHS hospital. In reality, PCT areas and the nearest NHS hospital areas overlap heavily. Results are invariant to which definition of supply is used.

[25]An NHS hospital (Trust) provides secondary (hospital) care to NHS patients in England. It is typically comprised of a hospital or number of hospitals run by the same hospital board, and is headquartered in the main or largest hospital.

[26]Hip replacements include those operations with Office of Population Censuses and Surveys (OPCS) Classification of Interventions and Procedures codes (4th Edition) beginning W37, W38, W39, W93, W94 and W95. Each operation code defines a different type of hip replacement. For a full list of OPCS codes see here: http://www.surginet.org.uk/informatics/opcs.php.

[27]Financial years run April to March. Emergency hip replacements are not used, because ISPs do not treat emergency patients and patients have no choice over where they are treated

[28]The nearest NHS hospital is defined by the nearest NHS Acute Trust headquarters that conducts hip replacements. The restriction to exclude ISPs conducting less than 20 procedures aims to concentrate on ISPs that are available to patients. This restriction removes 34 of the 140 ISPs that were operating in 2010/11, which accounted for just 3% of ISP patients. Robustness tests will estimate results with a minimal threshold of 5 ISPs, which account for all but 0.3% of patients.

m in PCT area p and year t is given by the following[29]:

$$Hips_{mpt} = \alpha + \beta ISP_{mpt} + \gamma_m + \mu_{pt} + \pi_t + X_{mpt} + \varepsilon_{mpt} \tag{1}$$

where ISP_{mpt} is a measure of the (relative) distance between the nearest ISP and the centroid of the patient's MSOA in year t. In our main specifications, ISP_{mt} is an indicator that takes the value 1 if the nearest provider of hip replacements in year t is an ISP. However, we also consider alternative specifications where we use continuous measures of the absolute distance to the nearest ISP and the distance relative to the nearest NHS hospital. The MSOA fixed effects, γ_m, control for permanent differences in the number of hip replacements across MSOAs, while π_t accounts for England-wide time trends. The PCT area specific time trends μ_{pt} control for PCT area wide factors that might change over time, and will include the average PCT area-wide effect of the introduction of an ISP. The coefficient of interest is β, the effect of introducing an ISP close to MSOA m on number of residents admitted for NHS-funded hip replacements, relative to the average effect across the patient's PCT area. This aims to capture the effect of ISPs on the volume of hip replacements generated by a shift in patient demand, as supply constraints are assumed to operate at the level of the PCT area. As we aggregate hip replacements provided by NHS hospitals and ISPs, substitutions between the two providers will not change overall volumes. The increase in volume generated by a rise in supply should be spread evenly across the PCT area and be captured by PCT area time trends. In the context of our results, we will refer to impacts on demand and impacts on volume as the result of shifts in demand interchangeably.

As with any fixed effects model, the principal threat to identification is the presence of contemporaneous shocks or trends that affect the volume of hip replacements in an MSOA, which are correlated with the introduction of ISP but are not captured by PCT area wide trends. We use two principal methods to address these concerns. First, in our baseline specifications we control for MSOA level characteristics that vary over time, X_{mt}. These include: (standardized) number of admissions for fractured neck of femur and acute coronary syndrome to capture population need[30]; nearest NHS hospital emergency readmissions to hospital within 28 days of discharge to provide a

[29] NHS-funded hip replacements are age and sex standardized to reflect the England-wide population distribution in 2001. This removes the impact of differential changes to the demographic compositions across MSOAs on the growth of hip replacements. We use a direct standardization method, which calculates the age and sex-specific hip replacement rates for each MSOA in each financial year, and multiplies this rate by the number of persons of each age and sex in a reference population. We use the England-wide population distribution in 2001 as the reference population (i.e. the mean number of persons in age and sex category in an MSOA in 2001).

[30] Fractured neck of femur and acute coronary syndrome are emergency conditions that typically affect older people. As admissions are nearly always an emergency, admission rates should reflect patient need and be uncorrelated with the introduction of ISPs, which only treat elective cases. As with elective hip replacements, admissions are typically for older people, although the average age of admission for the two emergency conditions is somewhat older. Finally, fractured neck of femur typically results in an emergency hip replacement, which uses the same surgeons and resources as elective hip replacements. Higher rates of fractured neck of femur admissions could therefore indicate both higher need in the population, as conditions such as osteoporosis increase the need for both elective and emergency hip replacements, and greater demand on local orthopedic units from emergency patients, which could result in longer waiting times for elective patients.

measure of the quality of the nearest NHS hospital; and number of house price sales and median house price, to account for changes in economic conditions[31]. The identifying assumption is that conditional on X_{mpt} and μ_{pt}, other unobserved and time varying determinants of hip replacements, ε_{mt}, are uncorrelated with the introduction of ISPs. This includes responses to falling waiting times and the introduction of increased choice in 2006. The standard error, ε_{mpt}, is robust to the presence of heteroskedasticity and clustered at the PCT area level, to account for ISP placement and funding decisions that take place at the administrative level.

Second, in Section 4.3.3, we address the non-random placement of ISPs using Instrumental Variables (IV) estimation, where the location of ISPs is instrumented with the presence of existing NHS and private health care facilities. It is however worth emphasizing that our baseline results are estimated *within* PCT. Any bias would therefore require that the location of ISPs within PCT areas was correlated with within PCT area variation in waiting lists or capacity constraints. Furthermore, although the introduction of the initial wave of ISPs was correlated with pent up demand, the precise timing of their introduction is likely to have been influenced by local contract or construction delays.

4 Results

4.1 Descriptive evidence on ISP use and distance

In our main specifications, where ISP_{mpt} is specified as an indicator for whether the nearest provider of hip replacement is an ISP, $\widehat{\beta}$ will capture an intensity of treatment effect on demand. The 2008 patient choice reform allowed patients to choose between any provider registered to provide NHS-funded care. In that sense, all areas of England were affected or 'treated' by the introduction of ISPs. However, existing empirical evidence suggests (relative) distance is a crucial determinant of a patient's hospital choice on the intensive margin, and we similarly expect distance to play a strong role on the choice on the extensive market of whether to seek treatment [*Beckert et al.*, 2012; *Varkevisser et al.*, 2010; *Kessler and McClellan*, 2000]. Moreover, prior to the patient choice reforms, the patient's nearest NHS hospital was typically the default treatment location, accounting for two thirds of all elective hip replacements in 2002/03 [*Kelly and Tetlow*, 2012]. We therefore define MSOAs as 'treated' if an ISP is introduced closer than the nearest NHS hospital.

Table 1 tests whether distance is a valid measure of intensity of treatment from ISPs. Column 1 shows the proportion of MSOAs that are treated in each year between 2002/03 and 2010/11[32].

[31] Population need characteristics are calculated using HES. Nearest NHS hospital characteristics are available via the NHS Health and Social Care Information Centre Indicators Portal (https://indicators.ic.nhs.uk/webview/). Information on house sales and prices comes from the Office for National Statistics (http://www.ons.gov.uk/ons/rel/regional-analysis/house-price-statistics-for-small-areas/1995-2013/index.html)

[32] There was no activity in 2002/03 and the small amount of activity in 2003/04 has been redacted due to the

Until 2007/08, the percentage of treated MSOAs fluctuated between 2% and 5%, reflecting ad hoc purchasing from the private sector. The share of treated areas rises rapidly thereafter, reaching 26% by 2010/11. For MSOAs that were treated in 2010/11, the average distance to the nearest ISP was on average 2.6km less than the mean distance to the nearest NHS hospital (10km)[33]. In these areas, the ISP reforms therefore reduced the average distance to the nearest provider of hip replacements by a quarter. This reduction in distance could have a direct effect on demand if patients and their GPs have a high preference for short travel distances, but closer proximity may also drive higher salience of the new entrants.

The second and third columns test the assumption that distance affects the likelihood patients choose an ISP by comparing the probability of treatment by the nearest provider type. In all years, the share of patients treated by ISPs is higher when the nearest provider to the centroid of the MSOA is an ISP. By 2010/11, 25.9% of all NHS funded hip replacements in areas with an ISP closer were delivered by ISPs, compared to 12.7% elsewhere. This confirms that the probability that an individual is treated by an ISP declines with (relative) distance, but that NHS hospitals remain the predominant provider of NHS-funded hip replacements, even in areas with a closer ISP. The final column shows that in 2010/11 just over two-fifths of the patients treated by ISPs live nearer to an ISP than their nearest NHS hospital, illustrating that although we define treatment as living closer to an ISP than an NHS hospital, patients in other areas also receive care from ISPs.

To assess whether the raw data provides any support for an effect of ISPs on total demand for hip replacements, Figure 6 plots the growth in the average number of NHS-funded hip replacements (the sum of those conducted by ISPs and NHS hospitals) per MSOA, by the nearest provider type in 2010/11 (NHS or ISP). Given that in 2002/03, the closest provider was always an NHS hospital, having a closer ISP in 2010/11 implies that an ISP began treating NHS-funded patients some time in the intervening period.

The solid black line shows the growth in the average number of hip replacements for the 79% of MSOAs where a NHS hospital remained the nearest provider in 2010/11. The gray line shows the growth in MSOAs where an ISP that conducted at least 20 hip replacements was the closest provider by the end of the period. There are two main points two note. First, the average number of hip replacements in the two types of area were very similar in 2002/03 at just under 6 per MSOA, before the ISP reforms were introduced, with slightly higher averages in areas where a NHS hospital remained the nearest provider in 2010/11. Second, as ISP started to open, hip replacement rates grew faster in areas where an ISP was the closest provider in 2010/11: the average number of hip replacements in areas where the nearest provider was an ISP in 2010/11 rose to 9.3 (or 67%) by the end of the period, compared to 8.1 (or 40%) in areas where the nearest provider was a NHS hospital. For the dashed line, we lower the procedure threshold for an ISP

small sample size.

[33] By way of comparison, the average distance between the centroid of an MSOA and the centroid of its closest MSOA is 2.3km.

from 20 to 5. As expected, the pattern is similar but somewhat weaker, as we expect that not all patients will have access to these smaller ISPs.

4.2 Fixed Effects

Table 2 provides the baseline estimates of (1). Column 1 includes only MSOA and year fixed effects. The specification therefore measures the combined effects on volumes of a relaxation in capacity constraints, and a potential shift in demand. The estimated coefficient suggests that the introduction of an ISP adds 0.87 hip replacements to the MSOA average, an effect which is statistically significant at the 1% level, and compares to an average volume of 5.8 procedures in 2002/03.

Column 2 adds PCT area specific time trends that control for all time varying factors at the PCT level, and controls for any impact on volumes through a PCT wide relaxation in capacity constraints. As expected, this reduces the magnitude of the estimated impact of the introduction of an ISP, which falls to 0.46 but remains significant at the 1% level. This suggests that demand shifts explain a sizable proportion of the overall change in hip replacement volumes. Adding our MSOA time-varying controls in column 3, has no effect on our coefficient of interest in terms of either magnitude or statistical significance.

An approximate cost to the NHS of the additional procedures can be calculated by combining the coefficients in Table 2 with the number of MSOAs that were treated and the NHS tariff for a hip replacement. In 2010/11, 1,761 MSOAs had an ISP conducting at least 20 hip replacements as their nearest provider. In the same year, the NHS tariff was approximately £5,000 [*Department of Health*, 2010]. Our most conservative estimate of the effect of ISPs on demand in column 3 therefore suggests an annual increase of 810 hips across England at a cost of £4.1 million or USD 5.3 million.

As discussed in Section 4.1, defining treatment as having an ISP as the nearest provider provides a proxy for intensity of treatment. However, intensity of treatment is not binary, and patient demand may be affected even in areas which have a nearer NHS hospital. In column 4, we divide relative distance into categories, and compare to areas where the nearest ISP is located 10km further than the nearest NHS hospital. In 2002/03 all areas fall into this category. Results indicate that the effect in areas where an ISP is the nearest provider is to increase the number of hip replacements by 0.63 hip replacements. However, there is an additional statistically significant effect for MSOAs where an ISP is less than 5 km further than the nearest NHS hospital of an extra 0.30 hip replacements. This illustrates that the effect of ISPs does decline with distance but remains statistically significant in areas where an NHS hospital is only slightly nearer. Using these coefficients, we calculate that in 2010/11 the increase in demand generated by ISPs is equal to 1,841 hip replacements at a cost of £9.2 million (USD 12.0 million).

In Appendix A, we consider different definitions of ISPs and alternative measures of treatment (including absolute and relative distance). The effect is to change the magnitude of the estimated $\widehat{\beta}$, but there remains a strong and statistically significant positive impact of ISPs on the level of demand in all specifications. We also re-estimate the specification in column 3 separately for three age groups: those under 60, those aged 60-79, and those aged 80 or over. The impact of an ISP opening is positive and statistically significant at the 1% level for all age groups[34].

4.3 Robustness tests and extensions

We now present three sets of robustness tests that underpin the credibility of our identification strategy, which: (i) assess alternative definitions of common supply; (ii) consider the potential for anticipatory effect or pre-trends; and, (iii) address the potentially endogenous placement of ISPs using instrumental variables analysis.

4.3.1 Supply Constraints

Our identification strategy outlined in Sections 3.1 and 3.2 assumes that we can identify a shift in demand for hip replacements by controlling for common supply factors that operate at the PCT area level (μ_{pt}). Our results could be biased if this assumption is incorrect. We test the validity of our supply-constraints assumption in two ways. First, we consider the relationship between ISP location and the waiting times of hip replacement patients. Waiting times are the principal mechanism for allocating NHS-funded treatment. If supply constraints do operate at the broader PCT area level, there should be no within PCT area differences in waiting times for NHS or ISP services. Using individual level data, we find that, conditional on provider type, there are no within PCT area differences in waiting times by relative distance to ISPs. In other words, the waiting times experienced by ISP patients and NHS hospital patients do not depend on distance to the nearest ISP[35].

Second, we re-estimate (1) using alternative definitions of supply. In particular, we replace PCT area time trends with nearest NHS hospital time trends, and then include both PCT and nearest NHS hospital time trends. In both cases the estimated effect of the introduction of ISPs remains statistically significant at the 1%, and the small reduction in magnitude relative to column 3 of Table 2 is not statistically significant[36].

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[34]For those aged 80 years or over, the introduction of an ISP as the closest provider increases elective hip operations by 0.09 hip replacements per year. This amounts to 9.8% of the average number of hip replacements per MSOA in 2002/03 and 6.5% of the average number of hip replacements in 2010/11. By comparison, for the under 60s, the estimated coefficient of 0.182 additional hips amounts to 10.3% of the average in 2002/03 and 7.2% of the total in 2010/11.

[35]Unconditional on provider type, patients living nearer ISPs have a shorter average wait time. However, this is entirely explained by the higher share of patients that are treated by ISPs in these area. Once we condition on provider type the differences disappear.

[36]We also consider changes in the PCT boundaries over the period. In 2006, the number of PCT areas was reduced from 303 to 152. We re-estimate the model using data from 2006 onwards and using the 2002 boundaries and find similar results.

As a final and related check, we tested whether growth in hip replacements between 2002/03 and 2007/08 varied by distance to the nearest NHS hospital and find no within PCT area variation. During this period, almost all procedures were conducted by NHS hospitals and waiting times fell rapidly. This indicates that in the absence of changes in hospital choice sets, patients do not respond differentially to falls in waiting times by distance to the nearest hospital.

4.3.2 Pre-trends

A potential source of correlation between ISP_{mpt} and ε_{mpt} is pent up demand for hip replacements in areas closer to ISPs. This could be for two reasons. First, ISPs may placed in areas where demand is increasing (shifting outwards) due to, for example, demographic pressures or differential responses to the 2006 patient choice reforms. Second, patients and doctors may delay procedures in the knowledge that an ISP will soon open.

In the first column of Table 3, we test for evidence of pent up demand by replacing ISP_{mpt} with a set of dummy variables for the year of entry, and 1,2,3,4 and 5 years post entry. The estimated coefficient on year of ISP entry is 0.40. This is statistically significant at the 1% level, and is not statistically different from our baseline estimate in column 3 of Table 2. The estimated coefficients on the variables indicating one, two and three years after ISP entry are of a similar magnitude and highly statistically significant.[37] This suggests that there was not an initial pool of patients that were waiting for treatment around the time of entry. The pattern is also more consistent with an effect of distance generated by the cost of travel, rather than informational frictions that would be expected to lessen over time.

Column 2 includes additional dummies for the three years before entry. The coefficients are smaller than in the post period, but still significant at least at the 10% level. This is explained by our definition of ISP_{mpt}, which only includes sites in our sample that conduct at least 20 hip replacements. We make this restriction as we think that small ISPs might not be in patient choice sets. However, this means that a site might start operating as a small ISP before it enters our samples in a later year. Patients in those areas will receive a weaker treatment in those preceding years, but this could still generate an increase in hip replacement patient numbers. In column 3, we remove MSOAs that were 'treated' by an ISP that conducted more than 5 but fewer than 20 procedures in a year prior to year that they treated by an ISP (usually the same hospital) that conducted at least 20 procedures[38]. When we make this restriction, the pre-entry dummies are not statistically significant, but there remains an effect-post entry. We also use the same sample and interact a dummy for ever being treated by an ISP conducting at least 20 procedures with dummies for 2002, 2003, 2004, 2005, the period before the expansion of ISPs, and find no statistically significant interactions.

[37] The estimates for four and five years after entry are of a similar magnitude, but are less precise given to smaller sample sizes.

[38] This restriction excludes 657 MSOAs, leaving 1305 treated MSOAs.

4.3.3 Instrumental Variable Analysis

The results in Table 3 do not suggest that there were any anticipatory effects or pre-trends in NHS-funded hip replacements prior to the introduction of ISPs. However, there remains a concern that the location of ISPs was endogenous to the potential demand. This is particularly the case in the first wave of the reform, as the aim was to use ISPs to cut long waiting times. Our final set of robustness tests therefore attempts to address this endogeneity concern by instrumenting ISP location.

4.3.3.1 The determinants of ISP placement

Table 4 shows the MSOA and nearest NHS hospital characteristics associated with having an ISP closer than the nearest NHS hospital in 2010/11. In all specifications, the dependent variable is an indicator that takes the value one if the closest provider of NHS funded hip replacements in 2010/11 was an ISP, and results are estimated using logit models. Column 1 includes measures of waiting times at the nearest NHS hospital and MSOA level, plus the average number of NHS hip replacements conducted in 2002/03 and 2003/04. These are factors that should influence location, as the initial objectives of the ISP reforms aimed to address capacity constraints and reduce waiting times. However, these determinants of location could also pose a threat to our identifying assumption, as one might expect areas with high waiting times or under-provision to experience greater growth in hip replacement volumes even in absence of the introduction of ISPs. The results indicate that the odds of an ISP as the closest provider in 2010/11 are increasing in the waiting times of the nearest NHS hospital in 2003, but there is no additional impact of waiting times within an MSOA. This suggests that ISP location is determined by factors at the PCT area or regional level, and not the characteristics of the much finer local area. Adding nearest hospital and local area characteristics in column 2 weakens the magnitude of the impact of nearest hospital waiting time on ISP location, but the pattern of results remains the same.

Column 3 introduces our potential instruments: the presence of pre-existing health care facilities that could be used to accommodate ISPs. Having a private 'hospital site' nearer than the nearest NHS hospital increases the odds of having an ISP closer by almost sixty-fold. An NHS 'hospital site'[39] nearer than the nearest NHS hospital conducting hip replacements increases the odds of having an ISP by 27%, although this effect is not statistically significant. This is because many ISPs are private hospitals operating in the NHS market, and are therefore located on the same sites as pre-existing private sites. The impact of nearest hospital waiting times is reduced in magnitude, indicating that existing health care facilities appear to be the dominant force in determining location. This seems plausible, given that land in England is scarce, and there are substantial constraints on where it is possible to build a hospital.

[39] Where a 'hospital site' is defined as a site with at least 30 beds and the words 'hospital' or 'infirmary' appear in the title

The criteria for a valid instrument are (i) that the instrument must be sufficiently correlated with the potentially endogenous variable, ISP location (the relevance restriction), and (ii) that the instrument only affects the outcome of interest (the volume of hip replacements) through its effects on ISP location (the exclusion restriction). The existence of existing health care facilities certainly fulfills the first criteria, but is unlikely to fulfill the second if the outcome of interest is the volume of hip replacements in a given year, as the location of these facilities is in itself non-random. However, the prospects are more promising if our outcome of interest is the change in the volume over some period of time. The Competition and Markets Authority Report into the private health care market in 2014 concluded that there are high barriers to both the entry and expansion of private hospitals [*Competition and Markets Authority*, 2014]. The stocks and locations of hospitals are therefore fixed in the medium term and determined by historical decisions rather than current NHS policy or recent changes in patient need. We exploit this feature to make the weaker assumption that the *change* in the volume of NHS funded hip replacements would be unaffected by the presence of a private hospital close by in the absence of the ISP policy. We therefore adopt a difference in difference style IV approach, instrumenting whether an ISP is introduced as the nearest provider with the location of pre-existing health care facilities.

4.3.3.2 Second stage results

To estimate the effects of the introduction of ISPs we estimate the following specification for the change in elective hip replacements between 2002/03 and 2010/11:

$$\begin{aligned}(Hip_{mp,2010} - Hip_{mp,2002}) &= \phi(ISP_{mp,2010} - ISP_{mp,2002}) + (\mu_{p,2010} - \mu_{p,2002}) + (\varepsilon_{mp,2010} - \varepsilon_{mp,2002}) \\ &= \phi ISP_{mp,2010} + \varphi_p + \epsilon_{mp} \quad (2)\end{aligned}$$

where our coefficient of interest is ϕ, the effect of the change in whether the nearest provider is an ISP[40], φ_p is a PCT area fixed effect, and ϵ_{mp} is the error term, which is clustered by PCT area.

Table 5 provides the estimates from our instrumental variables model. In all cases, the dependent variable is number of NHS-funded elective hip replacements conducted in 2010/11 minus the number conducted in 2002/03. Columns 1-3 present our baseline OLS estimates, and indicate a rise of 0.73 hips per MSOA just controlling for PCT area fixed effects and 0.70 when changes in time varying controls are added to improve precision. These are larger than the estimates in Table 2 as these coefficients were an average over earlier years, when new ISPs treated fewer patients.

Column 4 presents a similar specification to column 2, but uses IV estimation. As motivated above, we use two instruments for the introduction of an ISP closer than the nearest NHS hospital by 2010/11: (i) the presence of an existing private hospital site and (ii) the presence of an existing

[40] This is necessarily equivalent to whether an ISP was the closest provider in 2010, as $ISP_{mp,2002}$ is always equal to zero.

NHS 'hospital site' that was previously unused for hip replacements. We create two indicators, which take the value of one if the respective site is closer than an NHS hospital in 2010/11, and zero otherwise. The estimated coefficient of 0.69 is slightly smaller than in column 2 but the difference is not statistically significant. Controlling for time varying MSOA characteristics in column 5 makes little difference to our estimates. Taking the IV estimate in column 4 would imply that ISPs generated an additional 1,215 hip replacements in 2010/11 at a cost of £6.0 million (USD 7.8 million). Further estimates using matching techniques provide similar results.

The validity of the results in Table 5 rest on the assumption that the change in NHS-funded hip replacements would have been unaffected by the relative distance to a private hospital in the absence of the ISP policy. Of particular concern is the potential bias introduced by the coincidence of the start of the great recession and the expansion of ISPs. If potential patients responded to the recession by substituting from privately-funded procedures, then our results may be biased, and the expansion of ISPs be the result of an increase in demand for NHS-funded procedures, rather than the cause. We examine whether our exclusion restriction is violated in a number of ways. First, we test whether there is a difference in the growth of hip replacements by (relative) distance to the nearest private hospital, when the private hospital does not become an ISP by 2010/11. Results show no statistically significant difference in growth rates, suggesting that having a private hospital nearby is not in itself associated with differential trends in hip replacement use.

Second, we address the concern that the entry of private hospitals into the ISP market was non-random with respect to potential demand for NHS-funded hip replacements. By 2010/11, 4 of the 5 largest hospital chains had entered the ISP market, but not every hospital within each hospital chain became an ISP and began to treat NHS patients. To address this potentially endogenous entry decision, we restrict our sample of ISPs to just one hospital chain, Ramsay Health Care, which acquired the Capio hospital chain in 2007 and made the decision that all hospitals should enter the ISP market [*Competition and Markets Authority*, 2014][41]. Re-estimating fixed effects and IV models with this Ramsay ISP sample, the estimates remain statistically significant and are similar to those in Tables 2 and 5. Finally, when we restrict the sample to the period up to and including 2007, before the recession took hold, the impacts of ISP placements remain statistically significant.

These robustness tests do not suggest that substitution from the privately funded to NHS funded sectors pre-empted the introduction of ISPs. Indeed, aggregate data suggest very little change in the annual number of privately funded procedures (around 10,000) that would compensate for the 12,000 hip replacements conducted by ISPs in 2010/11, or even the 810 that we estimate as coming from a shift in demand. However, given the importance of potential substitution from the privately funded to NHS funded sections for both the validity and interpretation of

[41] As a consequence, Ramsay Healthcare accounted for 27.6% of all NHS-funded elective surgery admissions to ISPs in 2011/12 [*Laing & Buisson*, 2013]. For the other 3 hospital chains, almost all hospitals (>90%) had entered by 2012/13 (authors' calculations using the National Joint Registry). The main difference between Ramsay and the other hospital chains is therefore in the timing of entry rather than whether the hospitals entered at all.

our results, we provide a formal analysis of substitution between sectors in Section 5.

5 Private Pay Substitution

As noted in Section 2.2, increase in hip replacements generated by the shift in demand following the introduction of ISPs may represent either additional procedures or substitution from privately funded to NHS funded procedures. The private pay sector plays a relatively important role in this particular market, comprising 20% of procedures at the beginning of the period. This is one of the reasons why private capacity was first used in the orthopedic sector.

Understanding the relationship between demand in the privately funded and NHS funded sector is important for validity and the interpretation of our results. As noted in Section 4.3.3, our results will be biased if an event, such as the recession, caused patients living near private hospitals to switch to NHS-funded procedures for reasons other than the introduction of ISPs. Even if there is no such bias, the extent of substitution matters for how we interpret what our results mean for welfare and competition. In terms of welfare, any substitution from the private-pay sector represents a transfer to patients who would otherwise have paid for the procedure. In terms of competition, substantial substitution would imply that for these patients NHS hospitals were unlikely to compete with ISPs. Additional funding for the procedures would necessarily flow to ISPs.

5.1 Estimating Substitution

Information on privately funded health care in England is limited. Existing work on the private health care sector in England has focused almost entirely on the purchase of health insurance, due to data limitations [*Propper*, 2000; *Propper et al.*, 2001; *Besley et al.*, 1999][42]. However, for elective hip replacements, we can make use of individual level data from the clinical audit of joint replacements in the UK, the National Joint Registry (NJR). The NJR was established in England and Wales in 2002 and requires that all providers of joint replacements submit details of each operation. The objective is to monitor performance of different implant and types of surgery, and to improve clinical standards. The principal advantage is that these data contain records of all hip replacements, irrespective of the provider type and how the procedure is funded. The disadvantages are two-fold. First, there is less information on the patient, and in particular where the patient lives. Whereas the analysis using HES in Section 4 uses the 6,781 MSOAs provided, the NJR only records the patient's postal district. These postal districts are larger, with 1,993 across England, and so contains more measurement error in distances between hospitals and patients. Second, the data quality prior to 2008/09 is poor, with missing procedures and missing information on how

[42] It should be noted that this literature typically dates back to the 1990s and early 2000s, before a large increase in funding to the NHS and strict waiting time targets [*Propper et al.*, 2010] that brought down waiting times.

procedures are funded. This means we are unable to observe the pre-reform period.

To estimate the impact of ISPs on the market for hip replacements we collapse the number of NHS-funded (conducted at NHS hospitals and ISPs) and privately-funded (private hospitals and NHS private patient units) hip replacements to the postal district level for each year between 2008/09 and 2012/13. To check that these data produce similar volumes to those in HES, we collapse HES to the postal district level and compare the number of NHS-funded hip replacements across data sources. The figures are presented in Table 6. From 2009/10 onwards, the average number of NHS-funded hip replacements is almost identical across data sources. The number of privately funded procedures remain stable at around 5 procedures per postal district throughout the period, indicating that the recession had a limited effect on demand.

The five year NJR panel is geocoded to include indicators for whether the provider nearest to the centroid of the postal district is an ISP or NHS trust in each year and augmented with PCT area indicators. We then re-estimate an adapted version of (1) at the postal district level. Results are presented in Table 7. Estimates presented in column 1 indicate that the entry of an ISP led to one additional hip replacement, statistically significant at the 10% level. The magnitude seems plausible, given that our MSOA estimates in Table 2 are just under 0.5, and postal districts are 3 times as big. In column 2, we consider the impact on privately funded procedures. Here the effect is small, positive and not statistically significant, suggesting very limited substitution. Column 3 estimates the impact on the sum of NHS and privately funded hip replacements and finds a positive effect of 1.2 hip replacements, statistically significant at the 5% level.

The final three columns present the same set of results, but raise the threshold for inclusion of providers to 50 hip replacements. This aims to compensate for the loss of precision, generated by the larger geographic units. Here we find that there are effects on both the number of NHS-funded and total hip replacements that is statistically significant at the 5% level. Again, the coefficient of interest is small and not statistically significant for the number of privately funded hip replacements. Taken together, the estimates in Table 7 provide support to the results in Section 4, by producing a similar set of results with different geographic units and a different data source. The absence of an effect on privately funded hip replacements helps maintain the assumptions underlying our IV analysis, and implies that the additional hip replacements represent new procedures rather than a substitution from the private pay sector.

These results are consistent with findings from an investigation of the private healthcare market by the UK Competitions and Markets Authority [*Competition and Markets Authority*, 2014]. Based on surveys of patients and hospitals, the report concluded that the markets for NHS and privately funded health care were separate. The report also states that the private sector had a large amount of spare capacity and ability to switch production capacity easily between treatment types[43]. This

[43]It should be noted that hip replacements may not be representative of other surgical procedures. Hip replacement patients are typically retired and are therefore more likely to pay out of pocket and less likely to be covered by employer based private medical insurance. The recession therefore had a smaller impact on their insurance coverage

explains why it was possible for private hospitals operating as ISPs to increase the number of NHS-funded hip replacements they delivered, while private pay patients remained unchanged and the ability to expand hospitals is limited.

The absence of substitution implies that increases in procedures generated by the impact of ISPs on demand, estimated in Section 4, represent new procedures that would not have taken place in the absence of the reforms within the given year. These additional hip replacements have two sources: (i) hip replacements that would otherwise have taken place at a later date or (ii) hip replacements that would never otherwise have taken place, because patients die or become too frail before they have a procedure[44]. It is important to note that these are exactly the same sources that explain the much larger total increase in the number of hip replacements over the period. The only difference, as highlighted in Section 2.2, is that the additional procedures arising through the demand channel do not provide indirect benefits to NHS hospital patients through lower waiting times, and do not place competitive pressure in the NHS. The principal beneficiaries of the policy are those who receive an additional hip replacement, which comes at a cost to the taxpayer funded NHS.

6 The Impact on NHS hospitals

The main objective of this paper is to understand whether the introduction of ISPs led to a shift in demand for hip replacements, rather than to consider the effects of ISPs upon NHS hospitals. As Section 2.2 makes clear, shifts in demand for NHS-funded procedures can have important welfare and public finance implications, while leaving the market for NHS hospitals untouched. However, the impact on NHS hospitals remains important, first because the reforms aimed to use ISPs to improve waiting times and quality at NHS hospitals, and second, because the impacts on NHS hospitals will provide a context within which to understand the implications of the demand shift that we estimate.

6.1 Hospital Outcomes

Existing work on the impact of ISPs on NHS hospitals has focused on the first wave of ISPs. *Cooper et al.* [2015], for example, consider the effects of the first wave of ISPs on local NHS hospital waiting

and on their already annuitized wealth.

[44] The age distribution of additional patients treated by ISPs suggests that at least some patients would have died without having a procedure. When the baseline specification (column 3 or Table 2) is re-estimated for those over 80 the coefficient is equal to 0.09 hip replacements. Combining this with the number of treated areas (1,761) gives an estimated increase in hip replacements of 158 per year. The estimated one-year mortality rate for an 80 year old in England is 4% for women and 5.5% for men (rising to 7.5% and 10.3%) by age 85 [*Office for National Statistics*, 2015]. Those over 80 who have a hip replacement might not be representative of the population over 80 as a whole. However, if we take mortality rates at the bottom of the age band and apply to the increase of 158, this would mean that 6-9 of the additional hip replacement patients treated in each year would not have survived to the next year.

times, case-load and clinical quality. They find that waiting times fell but caseloads remained unchanged, as is consistent with Figure 4, and hospital efficiency improved, as measured by pre-operative length of stay. They also find that case-mix in NHS hospitals became more costly. However, as noted in Section 2.1, this is in part a mechanical consequence of NHS regulations, which specified that ISPs could not treat more complex patients.

To consider the impact of both waves of ISPs on NHS hospitals and their patients, we collapse hip replacement numbers, mean waiting times, and mean pre-operative length of stay to the NHS hospital year level[45]. The 9-year hospital panel contains the 133 NHS hospitals that treat more than 20 patients in all years[46]. The potential exposure of hospitals to ISPs is proxied by assigning each MSOA to their nearest NHS hospital, and calculating the share of those MSOAs in their catchment area that have a closer ISP than the NHS hospital. In 2002/03 the average share was zero, as no ISPs had opened. By 2010/11, the mean share of MSOAs within an NHS catchment area was 19.8% (median 13.7%).

Estimates presented in Table 8 consider the effect of changes in exposure to ISPs on the change in our three outcomes between 2002/03 and 2010/11[47]. The first set of specifications are estimated using OLS. The second set of specifications addresses the potentially endogenous placement of ISPs, by instrumenting the change in our exposure measure with the percentage of MSOAs within each hospital's catchment area that had a closer private hospital site in 2002/03 (see Section 4.3.3). Results for waiting time and volumes are consistent with both Figure 4 and the results from *Cooper et al.* [2015]. The growth of ISPs has no statistically significant impact on hip replacement volumes in NHS hospitals, either in OLS or IV, with the coefficients presented in columns 1 and 2 both imprecisely determined and close to zero[48]. This suggests that NHS hospitals are operating in the vertical portion of their supply curve. By contrast, there is negative and statistically significant effect of ISPs on waiting times in both the OLS and IV estimation. The OLS estimate in column 2 indicates that moving from a zero share to the mean share of 0.2 reduced waiting times by 12 days. The IV estimates are larger, with moving to a mean share reducing waiting times by 34 days. This compares to an average reduction in waiting times of 150 days over the 8 year period we consider[49]. Finally, in contrast to *Cooper et al.* [2015], we find no effect of ISP exposure on pre-operative length of stay[50].

[45]Waiting times are defined as the difference between the date of the decision to admit the patient for the procedure by the outpatient consultant and the patient being admitted to hospital for the procedure. It does not include the wait for an outpatient appointment.

[46]This compares to 159 hospitals that conducted hip replacements over the period. Most of those excluded had merged over the period we consider. All ISP patients are excluded from the analysis.

[47]As there were no ISPs in 2002/03, the change in ISP exposure between 2002/03 and 2010/11 is equal to the level of exposure in 2010/11.

[48]The estimated coefficients of a change of 2 hip replacements per hospital in column 1 and 4 hip replacements in column 2 compare to an average increase over the period of 83 hips replacements per hospital.

[49]This pattern of results remains unchanged if we consider the period 2006/07 to 2010/11, when we reduce the procedure threshold for ISPs to 5 procedures, and for both first and second wave ISPs.

[50]This contrast could potentially be explained by three factors. First, we examine a longer time period. Second,

6.2 Implications for the public finances and hospital competition

Results in Table 8 indicate that the main effect of ISPs on NHS hospitals and their patients was to reduce waiting time. The absence of a change in the quantity of procedures indicates that hospitals are operating on the vertical portion of their supply curve, so that inwards shifts in the demand for their services did not lead to a reduction in volumes and therefore revenues. This has at least two important implications.

First, any short run changes in volumes of elective health care are likely to have a permanent impact on the public finances, which must be weighed against improvements in patient welfare. The theoretical predictions in Section 2.2 and the empirical results show that ISPs volumes can increase volumes through both lifting capacity constraints (or an increase in supply) and a shift in demand. *Fordham et al.* [2012] find that elective hip replacement patients receive an additional 0.8 Quality Adjust Life Years (QALY) over the subsequent 5 years. Given that the costs of an NHS funded hip replacement are around £5,000, this implies a cost per QALY of just over £7,000. Where these additional patients would otherwise have died without the procedure, this is expenditure that cannot be recouped. Where procedures would otherwise have taken place at an NHS hospital at a later date, bringing treatment forward to this year from next year will reduce the demand for an elective hip replacement the following year for that patient, but there will remain a queue of patients ready to have treatment in their place. In other words, bringing forward procedures will not lead to a compensating fall in volumes in subsequent years driven by reduced demand.

Second, for patient choice to increase competition for NHS hospitals and drive improvements in quality, policy design must consider both the supply and demand for NHS care. The ISP reforms, which expanded patient choice sets, were introduced during a period where NHS funding was increasing rapidly. This enabled NHS hospitals to maintain their volumes, while the market share of ISPs rose to 20%. The impact upon NHS hospital revenues and therefore pressures to improve efficiency were therefore muted. The current supply context is very different with the NHS facing much stricter funding constraints. It is therefore likely that the impact of the ISP reforms would have had a different impact on overall volumes and NHS hospitals if introduced a decade later.

7 Discussion

This paper has examined whether and how reforms that allowed private providers access to the market for NHS funded elective care affected demand for elective hip replacements. We provide three main results. First, we find evidence that the introduction of ISPs led to a rise in hip replacement volumes generated by a shift in demand, in addition to increases driven by the shift

we analyse the impact of a wider set of providers. In contrast, *Cooper et al.* [2015] focus only on the introduction of wave 1 providers (or Independent Sector Treatment Centres). Finally, the definition of geographical 'treatment' by an ISP differs across the two papers.

in supply. In particular, our results suggest that when an ISP is introduced closer than the nearest NHS hospital, NHS-funded hip replacement numbers increase by 0.5 procedures per MSOA per year. This is equal to around 9% of the average number of 5.8 hip replacements per MSOA in pre-reform 2002/03 and a fifth of the average rise of 2.6 hip replacements between 2002/03 and 2010/11. Second, there is no evidence that the additional hip replacements generated by the demand shift reflect substitutions from the private pay sector. These hip replacements are instead procedures that would not have been carried out in the given year in the absence of the ISP program. Third, the ISP program reduced waiting times at NHS hospitals but had no effect on volumes and therefore revenue. This suggests that the relatively loose funding constraints in the 2000s allowed ISPs to expand, while placing limited competitive pressure on NHS hospitals. Together our results have the following implications.

First, and most broadly, our results show that increasing choice for consumers of public services when there is an outside option can affect the level of demand. This is important as additional service use generates increased consumer welfare but also higher fiscal costs. Moreover, shifts in demand following private sector entry do not stimulate the competitive pressure envisaged by the reforms. In the hospital sector, our results suggest the impacts on patient demand should be taken into account considering whether services should be centralized in particular hospitals, or when hospitals merge. For community health, our findings may have implications for the provision of services such as vaccination clinics or community pediatric care. Outside healthcare, we would expect very similar mechanisms to operate in the market for junior college in the US or Further Education colleges in the UK [*Currie and Moretti*, 2003; *Manski and Wise*, 1983; *Montgomery*, 2002]. What we cannot answer using our identification strategy is whether the type of provide matters. We identify shifts in demand that follow the new availability of private hospitals, but we cannot assess whether the same shifts would have been observed if public hospitals had been opened in the same locations in their place.

Second, we find no evidence that the increased demand for hip replacements represents substitutions from the private pay sector. Our results therefore support the findings from the recent UK Competition and Markets Authority that the NHS and private pay markets are separate [*Competition and Markets Authority*, 2014]. The additional procedures were new, at least in the given financial year. In terms of welfare, this implies that the ISP program did not result in transfers to consumers who would otherwise have paid. This finding also suggests that the sectors exert only limited competitive pressure on one another.

Finally, our results have important implications for understanding how the ISP reforms affected NHS hospitals and the wider NHS. In particular they highlight the importance of understanding both supply and demand within the NHS. We find that the introduction of ISPs did reduce waiting times at NHS hospitals, in line with the initial objective of the reforms, but volumes and hospital revenues were unchanged. This highlights that under a system where healthcare is rationed through waiting times, there is always likely to be a queue for elective conditions. Increasing supply for procedures will increase volumes this year, but even if these procedures are simply brought forward, volumes next year will not fall. Patients who were treated or were treated earlier as a result of the ISP program experienced an increase in welfare, but this also generated a permanent increase in costs for the public finances. In terms of competition, the pressure felt by NHS hospitals will depend upon the funding constraints that control supply. During the period ISPs were introduced, there was sufficient funding to enable NHS hospitals to maintain their volumes while ISPs expanded to 20% of the hip replacement market. This muted the competitive pressure felt by NHS hospitals, and therefore the likely impact on quality and efficiency. It is likely that both the change in overall volumes and the impact on NHS hospitals would have been very different had the expansion in ISPs occurred after NHS budgets tightened after 2010.

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A Alternative definitions of ISPs and Treatment

The first three columns of A.1 consider alternative definitions of ISPs. In the first column, we reduce the thresholds for ISPs included in our sample to five procedures. The effect is cut our coefficient of interest in half. This is unsurprising, because smaller ISPs offering very few procedures are not necessarily available to all patients. Lowering the threshold from 20 to 5 procedures increases the number of ISP sites by 22%, but these sites only treated 2.7% of all ISP patients. Columns 2 and 3 divide ISPs into Treatment Centres and Private Hospitals. Treatment Centres (or Independent Sector Treatment Centres) were established solely to treat NHS patients in the first wave of the reform. The effect of introducing a Treatment Centre is somewhat larger than our baseline estimates, at 0.67 hip replacement. "Private Hospitals", in column 3, which started operating as ISPs in the second wave of the reform were existing private hospitals that treated NHS and privately funded patients alongside one another. The estimate effect is very similar to the baseline result, in large part because most ISPs were private hospitals rather than ISTCs.

The final two columns redefine treatment as a continuous measure of distance rather than a binary indicator for relative distance. In column 4, we consider the distance from the MSOA centroid to the nearest ISP relative to the nearest NHS hospital; in column 5 we use the absolute distance to the nearest ISP. In both specifications, an additional km reduces the total number of hip replacements by 0.02.

Taken together these results indicate that altering the definition of either ISPs or MSOA treatment does effect the magnitude of our estimates. However, the main conclusion that the introduction of ISPs increases demand for elective hip replacements remains unchanged.

Table 1: ISP treatment and volumes of hip replacements 2002/03 to 2010/11

	% ISP Nearest Provider	% of MSOA hips conducted by ISPs		% ISP hips for pats with ISP closest
		NHS closest	ISP closest	
2002/03	0	0	0	0
2003/04	0	0	0	0
2004/05	3.5	1.3	6.9	12.3
2005/06	3.3	2.1	9.5	15.2
2006/07	2.0	2.9	23.1	15.1
2007/08	4.4	5.8	28.7	20.7
2008/09	13.6	8.2	22.1	32.5
2009/10	13.3	9.6	25.2	30.4
2010/11	26.0	12.7	25.9	43.9

Notes: Author's calculations using HES inpatient data April 2003 to March 2011, collapsed to the MSOA level. There was no ISP activity recorded in HES in 2002/03. Figures for 2003/04 have been omitted due to the small sample size.

Table 2: Fixed effects estimates of the effect on ISPs on standardized elective hip replacements per MSOA

	(1) MSOA FE	(2) PCT TT	(3) +controls	(4) Rel Distance
ISP location				
ISP closest provider	0.868***	0.462***	0.457***	
	(0.158)	(0.114)	(0.113)	
ISP distance relative to nearest NHS hospital				
5-10km further				-0.0215
				(0.0953)
0-5km further				0.304**
				(0.136)
ISP closer				0.626***
				(0.168)
MSOA characeristics				
FNOF admits			0.0131*	0.0130*
			(0.00690)	(0.00690)
Acute coronary syndrome admits			0.00475	0.00471
			(0.00459)	(0.00459)
House sales			0.000803*	0.000797*
			(0.000468)	(0.000466)
Median house price (£000s)			0.00155*	0.00158**
			(0.000798)	(0.000797)
Nearest NHS Hosp characteristics				
28 day emergency readmission rate (%)			-0.0172	-0.0206
			(0.0370)	(0.0382)
Standardised AMI mortality rate (%)			0.218	0.147
			(1.120)	(1.086)
MSOA Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
PCT area x Year Fixed Effects	No	Yes	Yes	Yes
Observations	61,029	61,029	61,029	61,029
R-squared	0.093	0.193	0.194	0.194
Number of MSOA	6,781	6,781	6,781	6,781

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. Observations are at the MSOA year level, and the sample includes all 6,781 MSOAs in England. The dependent variable in all columns is the number of admissions for an NHS-funded elective hip replacement amoungst MSOA residents, age/sex standardized to the English population in 2002. Relative distances to the nearest ISP and NHS Acute hospital are measured in straight lines from the centroid of the MSOA to the provider post (zip) code. Standard errors are robust to the presence of heteroskedasticity and clustered at the Primary Care Trust (PCT) area level.

Table 3: Robustness: Trends Pre and Post ISP Entry

	(1) ISP20 post years	(2) ISP20 including pre	(3) Excluding ISP 5
Years before and after ISP entry			
Year of entry	0.395***	0.568***	0.523***
	(0.127)	(0.165)	(0.147)
One year after entry	0.382***	0.577***	0.477**
	(0.140)	(0.165)	(0.190)
Two years after entry	0.475***	0.683***	0.483**
	(0.167)	(0.202)	(0.196)
Three years after entry	0.482**	0.725***	0.601**
	(0.225)	(0.249)	(0.245)
Four years after entry	0.491	0.742**	0.598*
	(0.351)	(0.360)	(0.328)
Five years after entry	0.543	0.797**	0.696**
	(0.355)	(0.369)	(0.341)
Year before entry		0.241*	0.103
		(0.143)	(0.147)
Two years before		0.388***	0.252*
		(0.121)	(0.148)
Three years before		0.184*	0.170
		(0.104)	(0.118)
MSOA Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
PCT area x Year Time Trend	Yes	Yes	Yes
Observations	61,029	61,029	51,156
R-squared	0.194	0.194	0.189
Number of MSOA	6,781	6,781	5,684

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. Observations are at the MSOA year level, and the sample includes all 6,781 MSOAs in England. The dependent variable in all columns is the number of admissions for an NHS-funded elective hip replacement amoungst MSOA residents, age/sex standardized to the English population in 2002. Distances are measured in straight lines from the centroid of the MSOA to the provider post (zip) code. The year of entry is the first year that MSOA had an ISP as the closest provider conducting at least 20 elective hip replacements within a financial year. In column 3, we exclude those MSOAs that had an ISP conducting more than 5 but less than 20 hip replacement procedures in any year before entry. Standard errors are robust to the presence of heteroskedasticity and clustered at the PCT level.

Table 4: The odds of having an ISP nearer than the nearest NHS hospital in 2010/11

	(1)	(2)	(3)
Nrst NHS Hosp Wait 2003 (SD)	1.432***	1.234**	1.1339**
	(0.132)	(0.119)	(0.176)
MSOA Wait Time 2003 (SD)	1.021	0.994	1.023
	(0.0417)	(0.0425)	(0.0584)
Average hip replacements in 2002 and 2003	0.997	0.948*	1.013
	(0.0172)	(0.0269)	(0.0409)
Private hospital close			59.25***
			(22.52)
NHS hospital site (>30 beds) close			1.265
			(0.306)
Nearest NHS Hosp Characteristics			
Teaching Hosp		1.504	1.092
		(0.400)	(0.377)
Dist (km)		1.250***	1.068
		(0.0511)	(0.0432)
Distance sq (km)		0.995***	0.998
		(0.00136)	(0.00106)
MSOA characteristics (2003)			
Fractured neck of femurs		0.996	1.008
		(0.0159)	(0.0267)
IMD score (2004)		0.992	1.015
		(0.0114)	(0.0175)
Population Density		0.994*	0.985***
		(0.00292)	(0.00433)
Population		1.000	1.000
		(0.00292)	(0.000254)
Unemployment (2004)		1.00	0.999
		(0.00154)	(0.00210)
Observations	6,719	6,719	6,719
Pseudo R-squared	0.0206	0.0916	0.458
Chi-squared (Private hospital and NHS site)			152.2

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. The dependent variable is an indicator equal to one if the straight line distance to the nearest ISP in 2010/11 is less than the straight line distance to the nearest hospital. Coefficients provide odds ratios from logistic specification.

Table 5: Instrumental variables estimates of the impact of ISP introduction on number of admittances for elective hip replacements per MSOA

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV
ISP location					
Change ISP closest provider	1.320***	0.730***	0.700***	0.691***	0.642***
	(0.235)	(0.167)	(0.169)	(0.227)	(0.228)
Change in MSOA characeristics					
FNOF admits			0.0618***		0.0617***
			(0.0195)		(0.0194)
Acute coronary syndrome admits			-0.0128		-0.0129
			(0.0135)		(0.0135)
House sales			0.00173		0.00173*
			(0.00106)		(0.00105)
Median house price (£000s)			0.00607***		0.00610***
			(0.00178)		(0.00176)
Change in Nrest hosp characteristics					
28 day emergency readmission rate (%)			-0.0539		-0.0545
			(0.0552)		(0.0547)
Standardised AMI mortality rate (%)			-2.378		-2.355
			(3.718)		(3.718)
PCT FE	No	Yes	Yes	Yes	Yes
Observations	6,781	6,781	6,781	6,781	6,781
R-squared	0.016	0.004	0.011	0.004	0.011
First-stage F-stat	-	-	-	168	167

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. Observations are at the MSOA year level. The dependent variable in all columns is change in the standardized number of elective hip replacements between 2002/03 and 2010/11 (standardized hip replacements in 2010/11 - standardized hip replacements in 2002/03). Relative distances to the nearest ISP and NHS hospital are measured in straight lines from the centroid of the MSOA to the provider post (zip) code. We include ISP sites that conduct at least 20 hip replacements in 2010/11. All covariates are expressed in terms of changes between 2002/03 and 2010/11. In Columns 4 and 5, whether the nearest provider was an ISP in 2010/11 is instrumented with whether there was a private or NHS hospital site nearer than the closest NHS hospital in 2002/03. Standard errors are robust to the presence of heteroskedasticity and clustered at the PCT level.

Table 6: The Introduction of ISPs and changes in NHS-funded and Privately-funded Hip replacements in the National Joint Registry, 2008/09 to 2012/13

	Funding Data Source:	(1) NHS HES	(2) NHS NJR	(3) Private NJR
2008/09		30.1	27.7	5.5
2009/10		30.3	29.5	5.2
2010/11		31.8	31.4	5.1
2011/12		34.3	33.6	5.2
2012/13		33.9	34.4	4.7

Notes: Individual HES and NJR data collapsed to the postal district level. Columns 1 and 2 include procedures conducted by NHS hospitals and ISPs. Column 3 includes privately funded hip replacements conducted at private hospitals and NHS private patient units.

Table 7: The Introduction of ISPs and changes in NHS-funded and Privately-funded Hip replacements in the National Joint Registry, 2008/09 to 2012/13

	(1) NHS funded	(2) Private funded	(3) All	(4) NHS funded	(5) Private funded	(6) All
ISP Closest Provider	1.004*	0.180	1.184**			
(threshold 20 procedures)	(0.524)	(0.152)	(0.504)			
ISP Closest Provider				0.786**	0.134	0.920**
(threshold 50 procedures)				(0.368)	(0.134)	(0.371)
2009/10	2.999***	0.217***	3.216***	2.759***	0.178**	2.937***
	(0.131)	(0.0380)	(0.126)	(0.230)	(0.0839)	(0.232)
2010/11	9.607***	-0.895***	8.712***	9.563***	-0.901***	8.663***
	(0.131)	(0.0380)	(0.126)	(0.138)	(0.0503)	(0.139)
2011/12	0.359***	-1.339***	-0.979***	-0.187	-1.434***	-1.620***
	(0.131)	(0.0380)	(0.126)	(0.138)	(0.0503)	(0.139)
2012/13	7.926***	0.448***	8.374***	7.435***	0.364***	7.799***
	(1.39e-09)	(8.82e-11)	(1.46e-09)	(0.230)	(0.0839)	(0.232)
Observations	9,864	9,864	9,864	9,864	9,864	9,864
R-squared	0.275	0.150	0.241	0.275	0.150	0.240
Number of Postal Districts	1,993	1,993	1,993	1,993	1,993	1,993

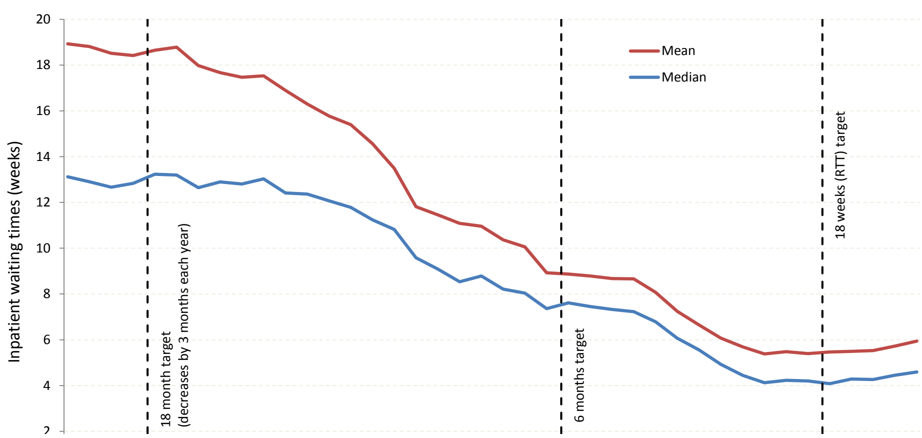
Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. Observations are a the postal district level. The dependent variable is number of hip replacements, age/sex standardized to the English population in 2002. Age/sex composition is calculated by aggregating the populations of the Lower Super Output Areas (Centroids) which lie in each postal code. All specifications include PCT area level time trends and postal area fixed effects. Standard errors are robust to heteroskedasticity and clustered at the Primary Care Trust level.

Table 8: Change in hip replacement patient numbers and mean waiting times in NHS hospitals and the introduction of ISPs, 2002/03 to 2010/11

	Δ Patients		Δ Mean waiting time (days)		Δ Mean pre-op length of stay (days)	
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	OLS	IV	OLS	IV
Change in Δ % MSOAs ISP closest provider	10.84	36.52	-65.71***	-130.4**	-0.00268	0.0982
	(42.92)	(103.3)	(23.45)	(62.04)	(0.188)	(0.419)
First stage F-stat	-	33.52	-	33.52	-	33.52
(% MSOAS Priv hosp closest 2002/03)						
Observations	133	133	133	133	133	133
R-squared	0.000	0.000	0.056	0.056	0.000	0.000

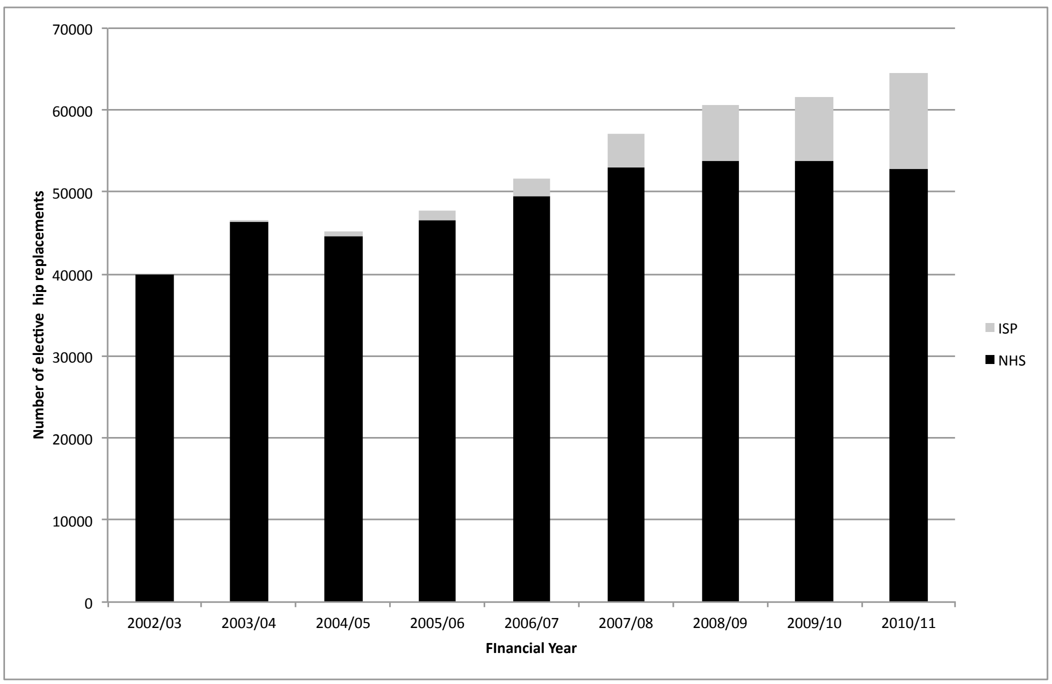
Notes: *** denotes significance at 1%, ** at 5%, and * at 1% level. Observations are at the hospital level The sample includes hospitals that data on waiting times and patient numbers in both 2002/03 and 2010/11. In columns 1 and 2, the dependent variable is the difference between the number of hip replacements conducted by the hospital in 2010/11 and the number of hip replacements conducted in 2002/03. In columns 3 and 4, the dependent variable is the mean waiting time for hip replacement patients in 2010/11 minus mean waiting times in 2002/03, where waiting times are the difference the date on which it was decided to admit the patient and the actual admission date, in days. The variable of interest in all columns is the change in % MSOAs where the ISPs is the closest provider between 2002/03 and 2010/11. This is calculated by assigning MSOAs their closest NHS hospitals, using straightline distance measures and calculating the share of these MSOAs that have a closer ISP in each year. Columns 1 and 3 are estimated using OLS. Columns 2 and 3 are estimated using IV where the change in % MSOAs where the ISPs is the closest provider is instrumented with the % of MSOA where was a private hospital site closer than the nearest NHS trust in 2002.

Figure 1: Mean and Median Inpatient Waiting Times (April 2000-January 2010)



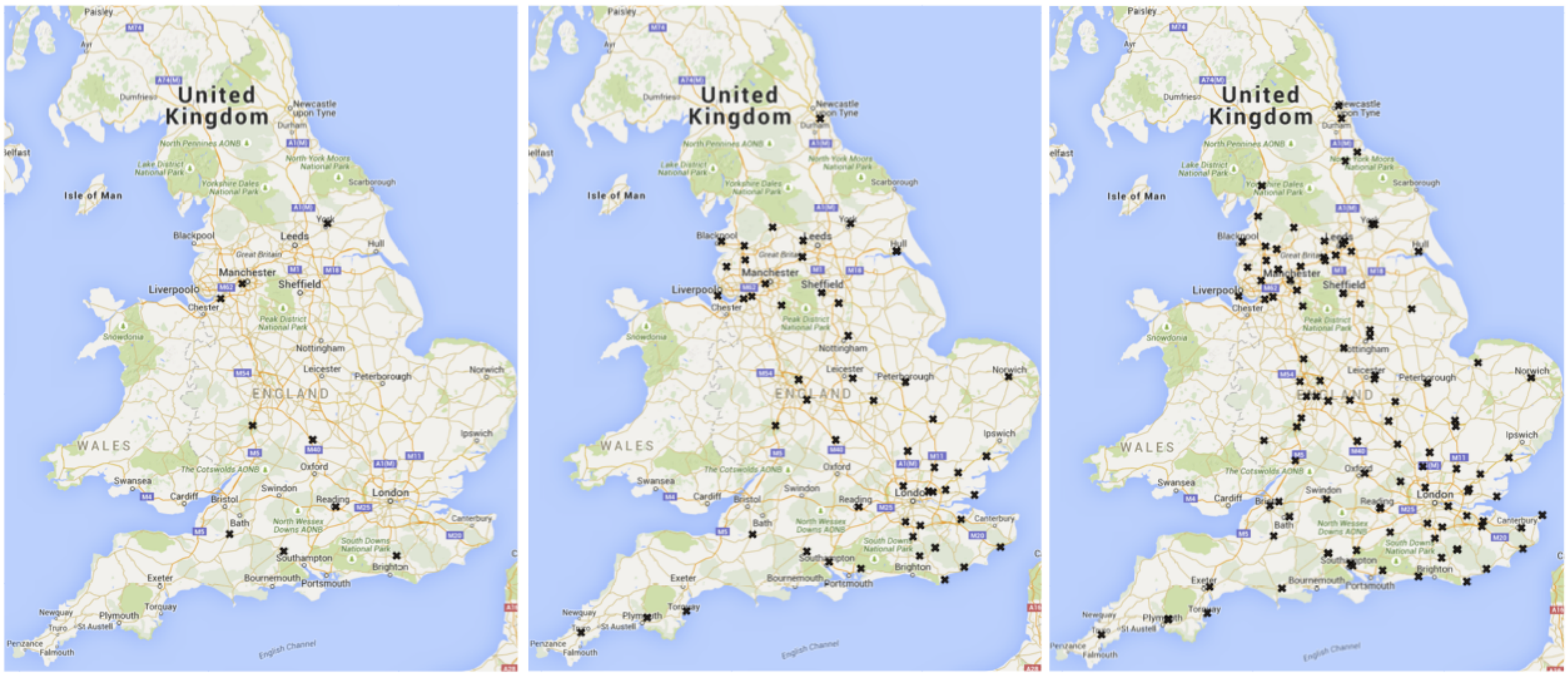
Source and notes: Department of Health provider-based median inpatient waiting times. Waiting times measure time elapsed between a consultant's decision to admit and the date of admission for an inpatient procedure, and does not include the time between GP referral and outpatient consultation(s). The first waiting times target was introduced in April 2001, with a maximum wait of 18 months between the decision to admit and inpatient admission. The target was reduced by three months each year. In December 2008 a new referral to treatment (RTT) target was introduced, with a maximum wait of 18 weeks between GP referral and inpatient admission.

Figure 2: Numbers of NHS-funded hip replacements by provider type, 2002/03 to 2010/11



Notes: Hospital Episodes Statistics, April 2002- March 2011.

Figure 3: The spread of ISPs across England (2006/07, 2008/09 and 2010/11)



2006/07 2008/09 2010/11

Notes: Sample is restricted to those Independent Sector Providers that are recorded as conducting at least 20 NHS-funded elective hip replacements in the NHS Hospital Episode Statistics in the given year

Figure 4: The market for elective hip replacements and the ISP reforms

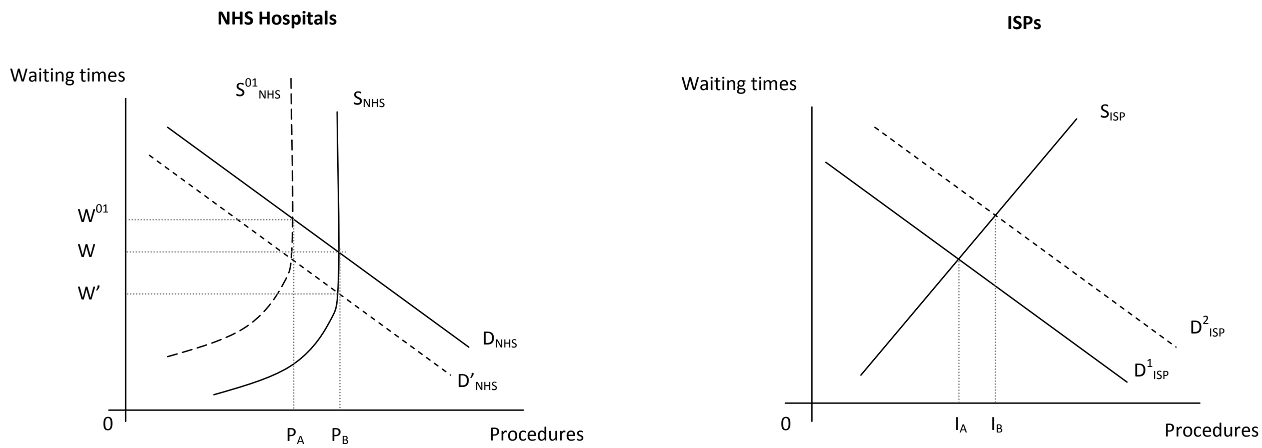


Figure 5: Separating demand from supply: An example from Leicester City Primary Care Trust

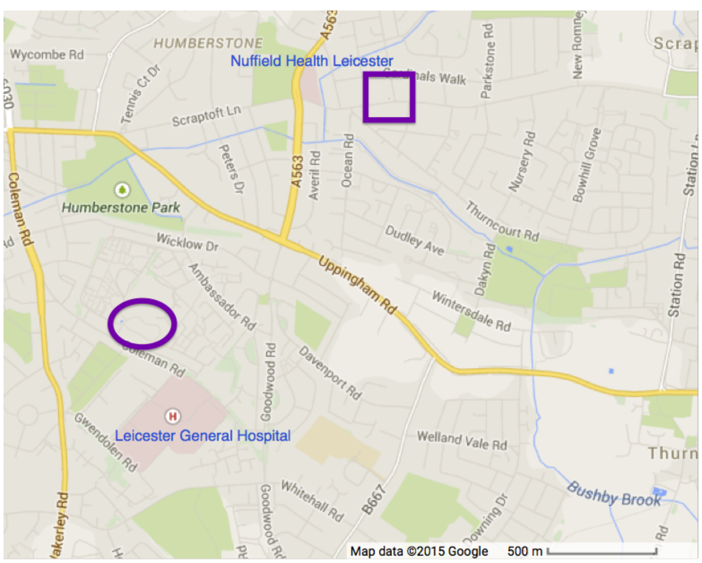
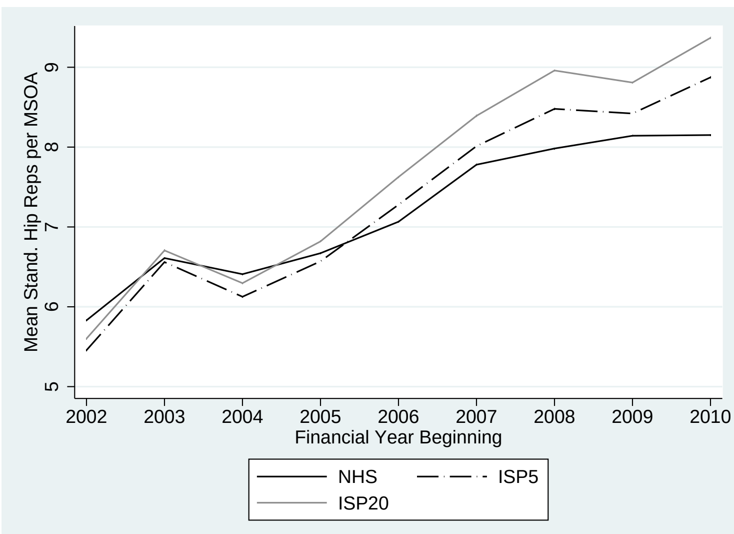


Figure 6: Mean standardized elective hip replacements per MSOA, by nearest provider type in 2010/11



Notes: The nearest provider (NHS or ISP) is defined as the nearest hospital that conducted at least 5 (or 20) hip replacements in 2010/11. All distances are measure in a straight line from the centroid of the MSOA to the full postcode of the NHS hospital or the ISP site.

Table A.1: Fixed effects estimates of the effect on ISPs on standardized elective hip replacements per MSOA for alternative treatment definitions

	(1) ISP5	(2) Treatment Centre	(3) Private Hosp	(4) Rel Distance	(5) Ab Distance
Sample	2002/03 - 2010/11			2004/05 - 2010/11	
ISP location					
ISP5 closest provider	0.209**				
	(0.0904)				
ISTC20 closest provider		0.600**			
		(0.262)			
AQP20 closest provider			0.428***		
			(0.124)		
Rel dist to nearest ISP (km)				-0.0139***	
				(0.00509)	
Dist to nearest ISP (km)					-0.0162***
					(0.00553)
MSOA characteristics	Yes	Yes	Yes	Yes	Yes
Nrest NHS Hosp characteristics	Yes	Yes	Yes	Yes	Yes
MSOA Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
PCT area x Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	61,029	61,029	61,029	47,467	47,467
R-squared	0.193	0.193	0.194	0.168	0.168
Number of MSOA	6,781	6,781	6,781	6,781	6,781

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. Observations are at the MSOA year level, and the sample includes all 6781 MSOAs in England. The dependent variable in all columns is the number of admissions for an NHS-funded elective hip replacement amoungst MSOA residents, age/sex standardized to the English population in 2002. ISP5 takes the value of one if an ISP conducting at least 5 NHS-funded hip replacements was the closest provider of NHS hip replacements in a given year. ISTC20 and AQP20 restrict the treatment variable to the appropriate type of ISP. Relative and absolute distances to the nearest ISP and NHS Acute hospital are measured in straight lines from the centroid of the MSOA to the provider post (zip) code. In columns (4) and (5), we include a quadratic term in relative and absolute distance respectively. Analysis is restricted to the period beyond 2004/05 in columns (4) and (5) as distance to large ISPs are undefined prior to 2004/05. Standard errors are robust to the presence of heteroskedasticity and clustered at the Primary Care Trust (PCT) area level.