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ABSTRACT

Cross-subsidies are often considered the principal mechanism through which hospitals provide unprofitable care. Yet, hospitals' reliance on and extent of cross-subsidization are difficult to establish. We exploit entry by cardiac specialty hospitals as an exogenous shock to incumbent hospitals' profitability and in turn to their ability to cross-subsidize unprofitable services. Using patient-level data from general short-term hospitals in Arizona and Colorado before and after entry, we find that the hospitals most exposed to entry reduced their provision of services considered to be unprofitable (psychiatric, substance-abuse, and trauma care) and expanded their admissions for neurosurgery, a highly profitable service.

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I. Introduction

Cross-subsidies are often considered the principal mechanism[1] through which hospitals provide otherwise unprofitable care (Phelps, 1986; Norton and Staiger, 1994; Banks et al., 1997; Banks et al., 1999; Horwitz, 2005; CBO, 2006; David and Helmchen, 2006, Vladeck 2006; Hseuh et al., 2009). Although there is clear evidence of regulation-driven cross-subsidization of otherwise unprofitable services in the transportation and telecommunications industries (Banks et al. 1999, Nicolas 1991; Chevalier, 2004), evidence of cross-subsidization in the hospital industry remains largely anecdotal and its extent is not well documented.

Hospital cross-subsidization is not transparent from an accounting perspective, and therefore direct observation of this practice and its extent is not possible. Instead, identification must rely on shocks affecting only profitable services, such that their effect on unprofitable services can only be channeled through cross-subsidization.[2]

In this paper, we use single-specialty hospitals' entry in the market for select procedures as a shock that affects incumbent hospitals' profits.[3,4] Although single-specialty entrants

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[1] Other mechanisms include DSH payments, bailouts, uncompensated care pools, tax exemptions, and donations. We examine each of these in the Discussion section.

[2] Unprofitable care, also referred to as *under-* and *uncompensated care*, includes free or discounted care, bad debt, as well as shortfalls from Medicare, Medicaid and other public programs. While U.S. hospitals provide approximately $30 billion in unpaid care annually, the practice of financing unprofitable care is not well understood (Nicholson et al., 2000; Vladeck 2006).

[3] The federal law defines a specialty hospital as one that is "primarily engaged in the care and treatment of cardiac, orthopedic, or surgical patients" (MedPAC 2005), omitting from this definition psychiatric, and long-term acute hospitals that also are all single-specialty hospitals.

hospitals carefully consider their potential competitors' provision of the contested services before entry, they are unlikely to consider explicitly the incumbents' provision of uncontested and unprofitable services in particular (Burns, David and Helmchen, 2011). At the same time, unprofitable services offered by incumbent hospitals will be affected if they rely financially on the profitable services contested by the entrant. In short, we posit that entry into a specific set of profitable services directly affects incumbents' profits but does not affect their provision of unprofitable services except through the shock to profits.

The theoretical foundation for this argument is presented in Faulhaber (1975), who develops a model of pricing by regulated firms and shows that cross-subsidization in a free market would lead to competitive entry and result in instability of the cross-subsidizing enterprise. This mechanism has not been investigated empirically in the hospital industry. Moreover, although the possibility of entry by specialty hospitals can challenge the financial resilience and mission-fulfillment capability of incumbent general hospitals, it is not clear if and how general hospitals reconfigure the scope, quantity and quality of their other, uncontested service lines in response to entry. Yet, the potential for adverse effects on general hospitals' ability to cross-subsidize unprofitable care led Congress to institute a moratorium in November 2003 that halted the entry of new single-specialty hospitals.[5]

[4] Reports by the Medicare Payment Advisory Committee (MedPAC) and the Government Accountability Office (GAO) found conflicting results on the effect of entry by specialty hospitals on community hospitals' revenues (MedPAC 2005, GAO 2003).

[5] While the moratorium ended in August 2006, no specialty hospitals entered the markets we study after this date.

The conditions for cross-subsidization across different service lines persist, in part because reimbursement for traditional Medicare and Medicaid admissions is based on non-market prices set by the Federal and state governments, respectively. These price distortions persist to the extent that service lines remain profitable or unprofitable for a much longer period than in industries that face market prices. As a result, cross-subsidization would be possible in the hospital industry even if Medicare was the only payer. Variability in the generosity of prices across service lines also occurs in the private market because prices will be a function of the ex-ante demand for services of insurers' beneficiaries (Capps, Dranove and Satterthwaite, 2003). Insurers will pay a premium to ensure broad access for services that treat diagnoses that are more common and predictable in order to make their health plans more attractive to firms and their employees.

Federal regulations also play a role in the persistence of profitable and unprofitable service lines. The Emergency Medical Treatment and Active Labor Act (EMTALA) limits the ability of a hospital to discriminate among emergency patients based on ability to pay. Under these rules, emergency patients must be stabilized before being discharged from the hospital or the emergency room, regardless of payer. Thus service lines that tend to attract a large number of underinsured emergency patients tend to be less profitable, conditional upon a hospital's location. No such restrictions are placed on elective or urgent care if the patient is otherwise stable and is not faced with imminent death in the absence of treatment. Thus, service lines for treatment that can be scheduled in advance lend themselves more easily for discrimination by insurers.

Although entry by single-specialty hospitals is plausibly exogenous to incumbents' provision of uncontested unprofitable services, the location of a new entrant within a market is not random. A potential entrant will consider the prospective demand for its services in the context of the competitiveness of hospitals that supply contested services proximate to its potential location. There may be unmeasured factors that lead a prospective entrant to choose one site over another. Unmeasured factors such as the availability of a suitable site is likely to only be indirectly correlated with the provision of uncontested services. However, unmeasured factors, such as the efficiency of or physician morale at incumbent hospitals in the immediate vicinity of the entrant may be directly correlated with the provision of uncontested services. We include an instrumental-variables specification that addresses these potential endogeneity concerns.

We study the effect of entry by three specialty cardiac hospitals in Arizona on the provision of psychiatric, trauma, and substance-abuse care by incumbent general hospitals.[6] These uncontested services are considered to be unprofitable (Horwitz, 2005; Vladeck 2006; Hseuh et al., 2009). We also test the effect of entry on incumbents' provision of neurosurgery, an uncontested but profitable service (Lindrooth et al. 2011). The response by incumbent hospitals to a negative profitability shock allows us to study the reliance of select uncontested services on cross-subsidization. We chose to study

[6] Tucson Heart Hospital entered Tucson in 1998 and was fully operational in 1999, Arizona Heart Hospital entered Phoenix in 2000; , and Banner Baywood Heart Hospital entered Mesa in 2003.

Arizona because entry occurred in two markets that are geographically well-delineated. In addition, entry was limited to cardiac specialty hospitals over a relatively short period of time, allowing us to use longer time series for the pre- and post-entry periods.

We find evidence supporting system-level cross-subsidization of services considered unprofitable. In addition, we find evidence of hospital systems shifting into other services considered profitable in response to entry. These responses increase with the degree to which their contested services have been impacted.

The paper is organized as follows: section II discusses our strategy for identifying cross-subsidization. Section III presents the methodology used for measuring hospitals' exposure to entry and its effect on provision of unprofitable services. Section IV describes the data. The results are discussed in Section V. Section VI concludes.

II. Identifying the effect of entry on the provision of unprofitable services

Entry of specialty hospitals into profitable service lines has the potential of compromising the ability of incumbent general community hospitals to cross-subsidize unprofitable services (Schactman, 2005; Schneider et al., 2005; Berenson et al, 2006; Shneider et al., 2007; Shneider et al., 2008; Tynan, 2009; Cassil, 2009; Al-Amin et al., 2010; Burns et al., 2010; Steinbuch, 2010). Most stand-alone specialty hospitals are for-profit entities (Hadley and Zuckerman, 2005; Guterman, 2006)[7] and many are at least partially owned

[7] The Centers for Medicare and Medicaid Services define a specialty hospital as either: (1) a hospital where more than two-thirds of Medicare inpatients fall into no more than two Major Diagnostic Categories, which encompass a range of similar Diagnosis-Related Groups (DRGs), or (2) a hospital where two thirds or more of Medicare claims are from surgical DRGs (McClellan, 2005). The Government Accountability Office (GAO, 2003) identified nearly 100 stand-alone specialty hospitals in three major categories: cardiac (17 hospitals), orthopedic (36), surgical (22). Women's hospitals and other types of specialty hospitals made up the remainder.

by physicians (Cromwell et al., 2005; McClellan, 2005).[8] They enter when they expect to make a profit and aim to attract patients suited for standard, low risk procedures that will maximize profitability, potentially leaving to incumbent hospitals disproportionately treat many high-risk patients with complex care requirements.[9] Indeed, specialty hospitals have been found to be more profitable than general community hospitals when all payer types are considered (GAO 2003; Iglehart, 2005), in part because specialty hospitals treat a lower percentage of severely ill patients than community hospitals (GAO 2003; MedPAC 2005; Barro et al. 2005; Mitchell 2005; Cromwell et al. 2005; Greenwald et al. 2006; Cram et al. 2005).

Entry of additional treatment providers in the market for contested services should be welcomed by patients because greater competition will tend to lower prices, in the form of a reduced time price of reaching the nearest provider of these services and potentially even in the form of lower fees and health insurance premia. However, entry may adversely affect the provision of uncontested services if it compromises incumbent hospital systems' ability to cross-subsidize less profitable or unprofitable services. For instance, cardiology and cardiovascular surgery diagnosis-related groups (DRGs) account for 25-40% of the average community hospital's net revenue (Casalino et al., 2003);

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[8] Physician ownership of specialty hospitals poses a particular organizational and financial challenge for general hospitals that compete in the same market. Physician-owners have a stake in the clinical and financial performance of the hospital and are a major source of patient referrals. Cardiac specialty hospitals in particular have a higher percentage of physician ownership on average than other types of specialty hospitals.

[9] Specialty hospitals tend to be concentrated in states that lack certificate-of-need (CON) laws; all specialty hospitals are located in 28 states, with two-thirds located in just 7 states (GAO, 2003). In addition, specialty hospitals tend to be located in high-growth metropolitan areas that lack a dominant community hospital, and that have a large, single-specialty physician practice group (Casalino et al., 2003).

entry by an aggressive competitor will put this revenue, and thus the incumbent’s overall financial viability, at risk.

Current studies of incumbent hospitals’ exposure to entry compare markets that experienced entry to markets that did not. A market-level measure does not take advantage of the considerable within-market variation in the substitutability of the new entrant's and the incumbent hospitals' contested service offerings. Forward-looking potential entrants evaluate very carefully and strategically their likely prospects of success if they decide to start offering services in a given market and in a given location. Entrants will enter markets based on their prospects of success and thus, the markets and sites that new entrants select are not randomly chosen and may differ systematically from markets that are not selected for entry. Moreover, some markets do not experience entry because incumbent hospitals succeed in deterring entry, for instance by allocating more resources to physicians attractive to single-specialty competitors (Burns, Walston et al. 2001; Burns, Alexander, et al. 2001; Dafny 2005; Dobson and Randall 2005; Berenson et al., 2006; Burns, David and Helmchen 2011). In the latter case, entry by single-specialty competitors will raise the bargaining power of physicians providing contested services, as these groups may credibly threaten the incumbent hospitals with defecting to the entering specialty facilities. As entry deterrence is likely to claim resources from incumbent hospitals, a failure to distinguish between markets that are not entry targets and those that are may mask the true effect of entry on the provision of uncontested services by incumbent hospitals.

By contrast, we directly measure the degree to which an incumbent hospital's services are substitutes for the entrant's. This enables us to exploit *within* market variation in the exposure to entry and thereby increase the efficiency of our estimates. Specifically, exposure to entry at incumbent hospitals is measured using the estimated change in medical and surgical discharges of contested services that is attributable to entry. This measure of exposure takes into account the degree of service overlap and the physical location of the incumbent hospital vis-à-vis the entrant. *Ceteris paribus* the more closely prospective patients can substitute the contested service from the incumbent provider for the entering competitor, the more exposed the incumbent is to the negative profitability shock due to entry.

We calculate the degree of exposure using the predictions from a logit demand model of a patient's choice of hospital. To this end, we calculated the predicted number of admissions with entry and then performed a counter-factual simulation to predict the number of admissions had entry not occurred. The difference between these two predictions provides an estimate of the change in cardiac admissions that are due to entry. We then sum the predicted change in admissions over all hospitals that are members of the same hospital system and create a dummy variable that equals one if the system-level change in admissions is greater than the 25th, 50th, and 75th percentile of the predicted change, respectively.[10]

[10] This dummy variable equals one for hospitals that are not in a system if the hospital-level change in admissions is greater than the 25th, 50th, and 75th percentile of the predicted change among hospitals, respectively.

As many hospitals are part of multi-hospital systems, the relevant economic unit for the study of cross-subsidization is not obvious. There are good reasons to consider the system as the appropriate unit of analysis (Bazzoli et al. 2000, Dubbs et al. 2004). After all, financial viability is meaningful at the system level, as cross-subsidization can take place across hospitals within a system, especially when systems take advantage of scale economies by concentrating service lines in a subset of their hospitals. Similarly, the geographic location of hospitals within a system may allow internal subsidies, with hospitals in affluent suburban neighborhoods subsidizing underfunded inner-city hospitals.

Hospital systems at the 25th percentile and above include hospitals that are the closest substitutes to the new entrant and are therefore most exposed to specialty entry. The substitutability with the entrant falls as we include hospitals in systems in the 50th and 75th percentile of exposure. We vary the cutoff for exposure as we do not know a priori which level of exposure represents a large enough shock to profits to affect the provision of uncontested services. We then model the provision of uncontested services as a function of each exposure measure and other hospital and patient characteristics specific to each uncontested service. We focus on three uncontested services that are commonly thought to be unprofitable (psychiatric, trauma, and substance-abuse care) and on one service thought to be profitable (neurosurgery).

We model the degree of impact based on the total number of admissions lost to the entrant. This simplifies the analysis considerably and will not affect our results as long as the affect of entry on a hospital or system's profits are a monotonic function of the admissions lost. This is likely to be the case because a specialty hospital is unlikely to be able to discriminate among patients based on the incumbent hospital the patients would have been admitted to had it not entered. In other words, our estimate of which incumbent hospitals are most impacted by entry will be affected because the specialty hospital will be just as likely to accept a desirable patient regardless of the patient's second choice of hospital[11]. Similarly, an estimate of the effect of entry on the private insurers price at incumbent hospitals will be proportional to the number of admissions lost to the entrant.

As discussed above, entry by specialty hospitals is not random, as both the timing and location of entry are contingent on current and expected future developments in the market for the contested services, such as changes in reimbursement policies, patient demographics, physician availability, and medical technology. The choice of market by specialty providers should be uncorrelated with developments in the market for the uncontested services.

However, within markets, it may be the case that a specialty entrant locates close to incumbents that are most vulnerable to competition in order to maximize its future prospect for success. For example, a site next to a poorly run incumbent hospital with discontent cardiologists will be relatively attractive to a new cardiac specialty hospital

[11] Physicians that admit to both a specialty hospital and an incumbent hospital would be able to observe the insurer and be in a position to choose where a patient has a procedure. The only way such an arrangement could affect our results is the unlikely case where the physician funneled ***unprofitable*** patients to the specialty hospital.

because it would be cheaper and easier to attract the cardiologists, and their patients, away from the incumbent hospital.[12] To the extent that such bias exists, its direction is not clear. If the discontent of physicians with the incumbent hospital is not limited to cardiologists then physicians in uncontested specialties will also be more likely to leave the incumbent hospital. In this case failure to address the endogeneity of the choice of entry site would bias the results in favor of cross-subsidization. On the other hand, it may be that adjacent incumbent hospitals are poorly run and thus particularly vulnerable to competition. A hospital may be inefficient to the extent that it does not have the management or systems in place to cross-subsidize, which would bias the results towards the null hypothesis of no cross-subsidization.

Hospital fixed effects control for time invariant factors potentially related to the entry decision and the market for uncontested services. However, time-varying hospital-specific factors could potentially bias our results. We include an IV specification to address this possible source of bias. We chose instruments that measure the cross-sectional pre-entry susceptibility of a hospital to entry and the attractiveness of each hospital's catchment area to a potential specialty entrant. The instruments are described in more detail below.

III. Methods

Uncontested services at hospitals with substantial service overlap with or in close geographic proximity to new entrants will be most exposed to entry. Thus a difference-

[12] This example is based on informal communication with general and specialty hospital executives in the Phoenix, AZ market.

in-differences approach using a market-level indicator of entry will capture the net effect of entry but will not differentiate between decreases in uncontested services at exposed hospitals and increases in uncontested services at hospitals that are not exposed.

We begin by describing our method for estimating each hospital system's exposure to entry through its impact on contested services and then estimate how the effect of entry on the provision of uncontested services varies by exposure.

Exposure is calculated using estimates of the effect of specialty hospital entry on the incumbent hospitals' admissions of patients for the contested service. First, the effect of entry on admissions at the incumbent hospital is estimated using the parameters of a logit demand model of hospital choice. To ease computational burden, we estimate a grouped conditional logit model in which the data are aggregated to the zip code – diagnosis pair level (Guimarães, Figueirdo, and Woodward, 2003). Next, using the parameter estimates, we estimate the expected number of cardiac admissions in each year over the entire sample period at the system and hospital levels, denoted $E(Admissions_{st}^{entry})$ and $E(Admissions_{ht}^{entry})$, respectively. The expected number of cardiac admissions at each hospital system if the specialty hospital had not entered the market is denoted $E(Admissions_{st}^{no\ entry})$ and $E(Admissions_{ht}^{no\ entry})$, respectively. The estimates without entry are derived by eliminating the specialty hospital as an option and re-normalizing the predicted probabilities so that they sum to one. We use the same parameter estimates to calculate the number of admissions with and without entry. For each system and hospital, the change in admissions resulting from entry at system s and hospital h is then calculated as:

$$(1) \quad \Delta Admissions_{st} = Admissions_{st}^{entry} - Admissions_{st}^{no\ entry}$$

$$\Delta Admissions_{ht} = Admissions_{ht}^{entry} - Admissions_{ht}^{no\ entry}$$

For the hospital that entered, $E(Admissions_{No\ Entry})$ will equal zero.

We assume that an incumbent hospital will respond to entry only when $\Delta Admissions_{.t}$ is large enough to warrant the fixed costs of changing service offerings. We set $Exposure_{.t}$ equal to one if $\Delta Admissions_{.t}$ is greater than a response threshold, $\Delta Admissions_{..}^{Threshhold}$, and zero otherwise:

$$Exposure_{.t} = 1 \quad \text{if } \left|\Delta Admissions_{.t}\right| > \Delta Admissions_{..}^{Threshhold}$$

$$Exposure_{.t} = 0 \text{, otherwise}$$

Our measure of exposure relies on the well-known independence of irrelevant alternatives (IIA) assumption that underlies multinomial logit demand models. In our context, this assumption maintains that the existence of a specialty hospital does not affect the desirability of one incumbent hospital versus another (i.e. the relative probability of visiting any two incumbent hospitals is unchanged, regardless of whether there was entry by a specialty hospital). Thus the addition of a specialty hospital will leave unchanged patients' relative probabilities of choosing incumbent hospitals.[13]

[13] This assumption is reasonable in our specification because, as is described below, we stratified the sample by diagnosis and estimated the model for medical and for surgical admissions separately. Furthermore, within these diagnosis and procedure categories we interacted the clinical supply characteristics of each hospital with the clinical diagnosis characteristics of each patient and also control for travel time from the patient's zip code to each hospital in the choice set. Patients reach each diagnosis node, not by choice, but by nature of their illness. Clearly if specialty hospitals induce demand for more intensive services then our specification that limits the IIA assumption to within diagnosis cells would lead

Changes in the total number of admissions due to entry will affect both $\Delta Admissions_{..}^{Threshhold}$ and $\Delta Admissions_{ht}$ leaving $Exposure_{ht}$ unchanged. For hospitals in systems $\Delta Admissions_{..}^{Threshhold}$ is based on the system-level exposure whereas the exposure of independent hospitals is measured using a threshold based on hospital-level exposure.

Entry may also affect the prices that hospitals charge private payers for the contested service. While we don't observe these prices, the effect of entry on prices could be approximated by calculating the value of a given hospital to an insurance network with and without entry (Capps, Dranove, and Satterthwaite 2003). The resulting change in value would be proportional to the change in price within the market. However, as this measure will be correlated with $\Delta Admissions_{ht}$, we would be unlikely to identify separate price and quantity effects in the analysis of the provision of uncontested services. Thus, we make the simplifying assumption that the effect of entry on private prices is proportional to the change in the number of patients.

We estimate the grouped conditional logit model separately for each market and separately for patients with medical and surgical cardiac diagnoses. Medical admissions occur at more hospitals than surgical admissions reflecting the complexity of cardiac surgery. In addition, admissions at specialty hospitals consist of a higher proportion of surgical admissions than at general hospitals.

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to higher estimates of exposure. However, it would not affect our analysis of uncontested services because the system ranking of exposure would be unchanged.

To investigate the effect of using a market-level versus system-level measure of exposure, we estimate a generalized negative binomial regression of the number of admissions for each uncontested service with hospital fixed effects.[14] The resulting parameter estimates are identified using difference-in-differences and we use robust standard errors with hospital level clustering (Bertrand, et al., 2004). The estimates with the market-level measure of entry reflect the net effect of entry and identification requires the use of a comparison state to control for contemporaneous trends.

We also measure the effect of exposure to entry on hospital market share, or equivalently, the probability a patient is admitted to an exposed hospital versus other hospitals in the patient's choice set. Exposed hospitals can reduce the supply of unprofitable uncontested services by reducing the number of beds available for the services, shutting down dedicated units that target uncontested services, or limiting admitting privileges of physicians in uncontested specialties. Closing beds reflects an additional cost for a patient admitted to an exposed hospital because his or her admission may be delayed due to capacity constraints. The closure of a dedicated unit will also decrease the attractiveness of a hospital relative to its competitors and thus reduce the utility and likelihood of an admission at the exposed hospital. An additional mechanism lies in patients' idiosyncratic valuation of a hospital. As is common in hospital choice models, we assume that the attractiveness of individual physicians to the patient is encompassed in his valuation of a hospital's idiosyncratic attributes because a patient's choice of a

[14] The hospital fixed effect are included directly in the model rather than integrated out of the likelihood function so as to mimic the difference in difference specification. Specification tests revealed that the data exhibited over-dispersion and that the degree of over-dispersion was a function of the market and a fixed indicator of whether the hospital was ever exposed to entry. Therefore we use a generalized version of the negative binomial regression and explicitly model the degree of over-dispersion.

physician occurs in tandem with his choice of a hospital. Thus if exposed hospitals reduce the supply of uncontested services by limiting the privileges of specialists of the service then the expected utility of an admission to an exposed hospital will also be lowered relative to its competitors.

This analysis enables us to estimate the degree of substitution that occurs between hospitals that are exposed and those that are not exposed. We model the probability of an admission for an uncontested service using a logit demand framework. The utility of patient *i* admitted to hospital *h* in time *t* for a diagnosis related to an uncontested service is:

(2) $$U_{hit}\left(Exposure_{ht}, \gamma_h, X_i, T_{hi}\right) = \beta_1 Exposure_{ht} + \tau_1 T_{hi} + \tau_2 T_{hi} \cdot X_i + \tau_3 T_{hi} \cdot \gamma_h + \theta_i + \varepsilon_{hit}$$

where $Exposure_{ht}$ is a dichotomous variable that measures whether incumbent hospital *h* is exposed to entry at time *t*; T_{hi} is the approximate travel time from patient *i*'s residence's zip code to hospital *h*. X_i is a column vector reflecting the patient characteristics and clinical attributes that affect demand for inpatient services; γ_h is a hospital fixed effect and θ_i. The final term in (2), ε_{hit}, represents the personal and idiosyncratic component of patient *i*'s utility of admission to hospital *h* at time *t*.

Under the logit demand assumption, the predicted probability of a patient with characteristics $\left(X_i, T_{hi}\right)$ of choosing a given hospital *h* from a set of *G* hospitals available at time *t*, is

(3) $$s_{ht}(G_t, X_i, T_{hi}) = \frac{\exp[U(Exposure_{ht}, \gamma_h, X_i, \theta_i, T_{hi})]}{\sum_{g \in G_t} \exp[U(Exposure_{gt}, \gamma_g, X_i, \theta_i, T_{gi})]}.$$

The parameter associated with $Exposure_{ht}$ measures the effect of entry in contested services on the probability a patient will be admitted to hospital *h* for an uncontested service. $Exposure_{ht}$ equals one if the hospital is exposed to entry and zero otherwise. We use a discrete measure of exposure because the decision to change the supply of uncontested services would only occur if the shock to a system's profitability was sufficiently large.

The specifications in Equations 2 and 3 are intentionally parsimonious. Hospital fixed effects control for service offerings that are fixed over the entire time period. We do not control for specialty service offerings that vary over time because hospital administrators may add or drop these services in response to entry and the inclusion of these changes over time would yield inconsistent estimates of the exposure. As a result our estimates capture all changes in specialty services offerings at more exposed hospitals relative to less exposed ones.

We estimate Equation 3 using a conditional logit model. We calculate robust standard errors with hospital-level clustering. Our specification is analogous to a difference-in-differences approach where the sample consists of admissions pre- and post- entry, the treatment is exposure to entry, and the outcome is the probability of an admission. The control group consists of hospitals located in Colorado or those located in Phoenix or Tucson but not exposed to entry.

As discussed above, when a cardiac hospital enters a market it will likely scout out potential sites and choose a site that best suits its objective. The potential entrant will therefore choose a location that is attractive to both cardiologists and their patients. In this case, the estimated effect of entry on a hospital's admissions will be correlated with unobserved hospital characteristics such as quality or managerial approach. If these characteristics are also correlated with the provision of uncontested services then the exposure of a hospital to entry may be correlated with the supply of uncontested services, thus making $Exposure_{ht}$ potentially endogenous.

We control for endogeneity using the two-stage method of residual inclusion because the main equation is nonlinear (Basu and Terza 2009). We chose two sets of instruments that (1) measure demand characteristics that affect the appeal of a hospital's catchment area for a specialty hospital and (2) measure the susceptibility of incumbent hospitals' profits to entry. We posit that the instruments we selected predict the exposure of an incumbent hospital to entry while at the same time are uncorrelated with unmeasured factors that would lead to both increased exposure and a deterioration of uncontested service demand. The first set of instruments measures the expected demand for cardiac services in each incumbent hospital's catchment area. Hospitals in market areas where there is a high demand for cardiac services and that draw patients from wealthier zip codes are more likely to face increased competition due to entry than other market areas, *ceterus paribus*. Conditional on hospital fixed effects, these instruments are unlikely to directly affect uncontested services.

The first set of instruments measure the total number of admissions in a hospitals catchment area that require cardiac catheterization, open heart surgery, or stent placements:

$$(4)\quad Catchment\ Area\ Admissions_{ht}^{d} = \sum_{z=1}^{Z} \frac{Zip\ Code\ Admissions_{zt}^{d}}{DriveTime_{z,h}}$$

where the superscript *d* indicates cardiac catheterization, open heart surgery, or stent placements; *Zip Code Admissions* is the number of admissions of residents in zip code *z* that require procedure *d*; and Drive Time is amount of time it takes to drive from zip code *z* to hospital *h.* We also calculated a measure of the hospital catchment area income using Equation 4 by replacing *Zip Code Admissions* with zip code per capita income. Equation 4 assigns greater weight to admissions and income at zip codes that are more proximate to a hospital. Large values reflect hospital catchment areas that are proximate to zip codes with a large number of patients with a given diagnosis or a higher income population. A hospital on the fringe of a metro area might have relatively low values for the diagnosis measures because the drive time to the hospital from the population center is relatively long. However, such a hospital may have a larger value on the income measure if the fringe of the metro area had higher average income than the population centers.

To measure the supply of cardiac services at each incumbent hospital taking into account system membership, the second set of instruments measure the number of open heart surgery units and cardiac catheter laboratories operated by a system or an independent hospital at the beginning of our sample period (1997). These variables measure the baseline susceptibility of the system's profits to competition in cardiac services. We fix the supply of these services to the 1997 level for two reasons. First, systems may close or drop services in response to entry and a contemporaneous measure of supply would be endogenous in the first-stage equation. Second, a potential entrant will choose among sites based on the expected supply of services at the time of entry. Finally, we measure supply at the system level because even if a hospital that is proximate to a potential site does not offer a service locally, specialist physicians commonly have offices at multiple sites but will perform more complicated surgeries at a particular branch within a system. Patients are typically willing to travel further for surgery than for less complicated care.

VI. Data

Our primary dataset is the Healthcare Cost and Utilization Project State Inpatient Database (SID), which consists of the inpatient discharge abstracts from all hospitals in Arizona and Colorado of all patients discharged between 1997-1998 and 2005-2007.

The sample includes admissions to all non-federal general or cardiac specialty hospitals in the Phoenix, Tucson, and Colorado's front range (including Boulder, Colorado Springs, and Denver) markets for contested and uncontested services. Colorado borders Arizona to the northeast, and the front range of Colorado is similar to Phoenix and Tucson in a number of ways. Both states have major population centers that are well delineated from surrounding areas. The front range of Colorado is bordered by the Rocky Mountains to the west and semi-arid grasslands to the east. Similarly, Phoenix and Tucson are surrounded by Sonoran Desert to the south and west and mountains to the north. These markets have a comparable prevalence of large local and national systems, reflecting a similar hospital regulatory environments. In addition, and perhaps most importantly, while no regulatory restrictions to entry were in place in either state, there was no specialty cardiac hospital entry in Colorado during the time period of our sample.

We limited the sample to a pre-period 1997-1998 and a three-year post-period 2005-2007 in order to capture the long-run effects of the shock. We expect there to be a lag between entry and the effect on hospital's profits. Furthermore, there is likely to be a lag between reduced profitability and decisions regarding service offerings. Tucson Heart Hospital opened Tucson in 1998 and Arizona Heart Hospital opened in Phoenix in 1999. Both experienced rapid growth in 1999-2000 but the growth leveled off after 2000. Banner Baywood Heart Hospital entered Mesa in 2001 and after two years of rapid growth its admissions stabilized after 2003. Furthermore, likely in response to entry, the composition of systems changed between 2000-2003 as hospitals realigned services to adapt to the new market structure.

Admissions to a contested service are defined as an admission in the Circulatory System Major Diagnostic Category (MDC 5). We examine the following uncontested services: Psychiatry (MDC 19); Alcohol and Drug Treatment (MDC 20); and Trauma (MDC 24), all commonly considered to be unprofitable services (Horwitz, 2005; Vladeck 2006; Hseuh et al., 2009). We also estimate the model using a sample of neurosurgery discharges. In contrast to psychiatric, substance abuse, and trauma services, neurosurgery is thought to be a profitable service (Lindrooth et al. 2011). As neither market in Arizona experienced entry into neurosurgery, we predict those incumbents most exposed to entry to raise, rather than reduce, the number of neurosurgery discharges.[15]

We restrict the sample to persons who were treated within their state of residence. Emergency admissions are identified using the admission type associated with the discharge. We do not distinguish between admissions from each payer because several hospitals did not consistently report payer type in the HCUP-SID data. However, the majority of admissions for cardiac care are either Medicare or private. Medicaid and self-pay admissions for cardiac care are relatively rare. We include a dummy variable that indicates if the payer was an HMO to control for the fact that HMOs use selective contracting which could result in idiosyncratic differences in travel patterns for these patients.

Travel times from the epicenter of each patient zip code to the address of the closest hospital-based service are calculated using data from Mapquest, Inc (Mapquest 2010). In the psychiatry sample we include the drive time to closest private specialty psychiatric hospital as a covariate to control for secular variation in access to substitutes to general hospital psychiatric admissions because the HCUP does not include discharges from specialty psychiatric hospitals.

[15] This prediction relies on the assumption that hospitals chose their pre-entry mix of profitable services optimally and were operating at capacity. If entry by specialty cardiac hospitals reduced cardiac admissions, space and time would be freed up to provide other services that require similar facilities and personnel.

We link the SID files to data from the American Hospital Association Annual Survey of Hospitals (AHA) to incorporate additional hospital covariates and merge in zip code level median income from the U.S. Census Bureau Population Estimates. System membership; the existence of a cardiac catheterization lab; and open heart surgery capability are also drawn from the AHA data. The hospital covariates included in each specification are listed in Table 1.

V. Results

Table 2 shows the net income from patients and the number of admissions for hospitals in Arizona by the estimated degree of exposure. The 25th percentile of exposure reflects hospitals in systems that experienced an estimated reduction of more than 786 admissions or for independent hospital a reduction of more than 416 hospital admissions. The threshold for the 50th percentile is 665 system-level or 210 hospital-level admissions and the threshold for the 75th percentile is 263 system-level or 87 hospital-level admissions for system and independent hospitals respectively. Overall, aggregate service offerings were unrelated to exposure. However, hospitals without an impact were much more profitable in the post period than in the pre period.

Trends in admissions for uncontested services are shown in Table 3 which includes the parameter estimates of an ordinary least squares regression of admissions on exposure and year and hospital fixed effects. The constant reflects the average number of admissions for each service line in 1997. Psychiatric admissions declined at exposed hospitals relative to the control by about 18-50 admissions (or 15-50%) depending on the degree of exposure. Trauma admissions were not significantly affected. Admissions for substance abuse declined by 38-60 admissions at exposed hospitals or 60-100%. Admissions for neurology increased at exposed hospitals but the coefficient is not statistically significant. Overall, admissions increased from 1997-2007, though they dipped in 2006 relative to 2007.

Table 4 shows the results of a negative binomial regression of the number admissions using a state-level measure of exposure pre and post entry. The coefficient estimates reveal a growth in the Arizona and Colorado markets of the number of psychiatric; trauma, and substance abuse admissions. The increase was smaller in Arizona but the coefficient is not statistically significant.

Table 5 shows the marginal effects based on the coefficient estimates from a generalized negative binomial count data model of the number of admissions at the system level. The estimates reflect the change in admissions related to exposure for three uncontested services: inpatient psychiatric services, trauma care, drug/substance abuse treatment. For each service we report coefficient estimates for three samples: systems above the top 25th percentile of exposure, systems above the top 50th percentile of exposure, and systems above the top 75th percentile of exposure. For each sample-service pair we report results with and without accounting for endogeneity.

The Shea partial R-squared from a linear probability model of the first stage ranges from 0.168 and 0.452. The Shea partial R-squared values for the hospital-level analysis are quite similar to those for the patient-level analysis. The F-test statistics at the hospital level range from 2.42 to 13.48 in the first stage of the negative binomial regression. However, the F-test statistics are very large in the patient-level first stage used in the conditional logit specification. Overall, the instruments are strong predictors of $Exposure_{ht}$ in the patient-level analysis.

For inpatient psychiatric services, hospitals more exposed systems had fewer yearly admissions post entry. The magnitude of the decrease ranges between 63.14 and 87.49 fewer psychiatric admissions, depending on the percentile of exposure and specification. When accounting for endogeneity, the decrease in the number of yearly psychiatric admissions is similar (between 66.6 and 84.03). Similar results are obtained for trauma care and substance abuse treatment, although the results are often not statistically significant.

Table 6 shows the coefficient estimates from the conditional logit model of the probability of admissions to a given hospital. The estimates reflect the change in the probability/market share of the hospital that is related to exposure for the three uncontested services. Among the 25% most exposed hospitals the market share of admissions for psychiatric services declined by 17.6 percentage points. The results are consistent with those presented in Table 3, and the reported estimates are statistically significant for all uncontested services. The likelihood of receiving care (for any of the three contested services) in hospitals that are part of exposed systems was significantly lower. Since the first stage residual is, for the most part, statistically significant, we trust the estimates from regressions adjusting for endogeneity, which are generally smaller than the unadjusted ones. As the definition of exposure was more inclusive, the estimates became smaller in magnitude. At the 75th percentile the estimate for psychiatric services was small and statistically insignificant and the estimate for trauma services turned positive.

Table 7 shows the results for admissions for neurosurgery. The first set of results are the marginal effects from the hospital-level negative binomial regression model (analogous to Table 5) and the second set of results are the change in market shares from the conditional logit model (analogous to Table 6). We find that hospitals exposed to entry in the top 25th percentile decreased their neurosurgery admissions though this result is marginally significant. The decrease is smaller and the standard errors are larger when the 50th and 75th-percentile cutoffs are used. This result is inconsistent with the trends in the linear fixed effect regression and the conditional logit analysis, where the probability of admission at hospitals above the top 25th , 50th and 75th percentile of exposure increased by 0.10 to about 0.20. By shifting to other highly reimbursed services, hospitals allocate resources away from contested services to partially offset the loss of patient revenue. This strategy would mitigate the effect on cross-subsidization, but is unlikely to fully offset the loss of revenue caused by specialty entry. If it did, that would indicate that hospitals were not allocating resources efficiently in the pre-entry period. This results suggests that systems do adjust their service offering of uncontested services (both profitable and unprofitable), and that the results in tables 3 and 4 represent the effect of entry that takes into account observed and unobserved adjustments made by hospital systems.

VI. Discussion

This is the first study to present systematic evidence of cross-subsidization of unprofitable service lines by using a shock to a profitable service line. We show that hospital systems adjusted their uncontested service offerings in the face of entry by single-specialty competitors. Consistent with cross-subsidization, reductions in the volume of psychiatric, substance abuse, and trauma care were greater among hospital systems most exposed to a potential loss in volume of their cardiac services.

We also find that the market share of neurosurgeries increased at exposed hospitals. though we do not find evidence that the total number of surgeries increased. These systems may have siphoned off neurosurgery admissions from less exposed systems or adjacent geographic regions. Alternatively, they may have succeeded in encouraging marginal patients who would have delayed or refused surgery otherwise to undergo the procedure. This suggests that systems unable to replace lost revenue from cardiac care with new revenue from neurosurgery volume may come under even greater pressure to reduce unprofitable services.

We focused on cross-subsidization across service lines, but there are several other mechanisms to support the provision of unprofitable care, regardless of a patients diagnosis. Governments provide special funding to hospitals treating a disproportionate fraction of low-income and uninsured patients through the Disproportionate Share Hospital (DSH) programs at the federal level and direct transfers at the state and local level (Duggan, 2000). An increasingly popular approach used in several states is to cross-subsidize unprofitable care across hospital systems using uncompensated care pools (Anderson et al., 2009; Bovbjerg et al., 2000). The transfers related to DSH payments and uncompensated care pools lessen the cost of cross subsidizing unprofitable services lines but we find that indirect subsidies alone are not sufficient to eliminate it. As specialty hospitals aim to treat well-insured patients, they are unlikely to affect either the DSH payments received by incumbent hospitals or the size of the uncompensated care pool.

Furthermore, it is not uncommon for communities to bail out hospitals that are considered to provide community benefits in order to prevent bankruptcy and closure (Capps, et al., 2010). Such subsidies are more likely if a hospital provides unprofitable services that are in short supply. Sole providers of unprofitable services in a community may be in a position to extract a subsidy from local governments in order to keep a service line open.[16]

There is an extensive literature on cross-subsidization in the context of privately owned regulated firms (Faulhaber, 1975; Peltzman, 1976; Nicolas 1991; Chevalier, 2004). Regulation of the transportation and telecommunications industries has broadly consisted of requirements for providing some services below average cost while using entry

[16] Similarly, nonprofit hospitals receive tax exemptions and can use the retained tax payments for this purpose, and a number of states have introduced explicit charity care mandates (Ginn and Moseley 2006; Nobel et al., 1998). Additionally, nonprofit hospitals may rely on unrelated business activity (Riley, 2007) and donations (Okten and Weisbrod, 2000; Leone and Van-Horn, 2005) to finance uncompensated care. While incumbent hospitals might react to entry by declaring bankruptcy or switching their ownership type.

restrictions to allow excess rents on other services. Airlines cross-subsidized lower-density traffic with profits from higher-density traffic, while railroads (prior to the creation of Amtrak in 1971) cross-subsidized unprofitable passenger services with profits from freight (Banks et al., 1999). In telecommunications, profits from long-distance services were used to subsidize local services (Nicolas, 1991). Over-time these regulations produced inefficient outcomes that eventually led to the deregulation of these industries (Peltzman, 1989; Banks et al., 1999).

Evidence of cross-subsidization by general hospitals does not mean, however, that this is an efficient way to achieve social goals such as supporting access to services or serving indigent patients (David and Helmchen 2006, Capps et al., 2010, Capps et al., 2011; Lindrooth et al., 2003). It may be advisable to preserve activities deemed socially vital, as opposed to preserving the mechanisms set forth to finance such activities. Our findings corroborate the conjecture that hospitals adjust downward their offerings of arguably unprofitable services in response to an adverse shock to services considered to be profitable enough to encourage entry by single-specialty hospitals. In light of these findings, a comprehensive welfare analysis of entry by single-specialty hospitals should include not only its market-wide effects on contested services but also consider its market-wide effects on uncontested services which rely on general hospitals' cross-subsidization efforts.

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Table 1. Summary Statistics

Sample:	Psychiatric	Trauma	Substance Abuse	Neurosurgery
Patient Characteristics				
Emergency Admission	39.50%	67.30%	58.70%	22.60%
HMO Primary Payer	17.7%	22.5%	20.9%	31.8%
Age 50-74	22.10%	28.60%	28.60%	48.20%
Age >74	12.70%	11.50%	4.68%	24.80%
Ln(Drive Time)	2.652	2.644	3.391	3.378
	(0.751)	(0.885)	(0.767)	(0.738)
# Procedures	0.269	1.561	0.659	2.592
	(0.724)	(1.981)	(0.860)	(1.665)
# Diagnoses	4.971	6.127	5.718	5.420
	(2.327)	(2.099)	(2.108)	(2.383)
Ln(Drive Time) interacted with:				
Age 50-74	0.588	0.773	0.973	1.639
	(1.165)	(1.310)	(1.591)	(1.773)
Age >74	0.326	0.286	0.163	0.838
	(0.899)	(0.853)	(0.753)	(1.506)
HMO Primary Payer	0.476	0.591	0.713	1.070
	(1.076)	(1.164)	(1.428)	(1.600)
# Procedures	0.702	4.396	2.210	8.740
	(2.027)	(6.196)	(2.974)	(6.074)
# Diagnoses	13.11	16.16	19.30	18.29
	(7.317)	(7.972)	(8.346)	(9.122)
Admissions	51,803	48,652	16,897	25,113
Hospital Characteristics (Weighted by Hospital Admissions)				
Phoenix	49.50%	59.00%	53.80%	60.10%
Tucson	17.90%	18.00%	17.30%	16.00%
System Exposure Top Quartile	7.14%	10.90%	6.94%	10.60%
System Exposure Median	14.80%	20.90%	15.00%	20.20%
System Exposure Top 3 Quartiles	23.50%	29.30%	26.00%	31.90%
Partial Year Data		0.42%	0.58%	0.53%
For-profit	24.00%	33.10%	20.80%	32.40%
Teaching	12.80%	10.50%	14.50%	13.30%
	Psychiatric Unit	Trauma Unit	Substance Abuse Unit	
Specialty Service Offerings: Hospital	66.80%	64.40%	23.10%	N/A
Specialty Service Offerings: System	44.40%	53.60%	22.50%	N/A
Hospital Years	196	239	173	188

Table 2. Net Income from Patients and Admissions for Arizona Hospital Systems Before and After Entry, by Exposure

	No Exposure		Top 25th Percentile		Top 50th Percentile		Top 75th Percentile	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Net Income from Patients (Median)	$768,151	$3,110,139	$312,606	-$680,824	-$576,530	-$329,053	-$759,803	-$477,308
Psychiatric Admissions	114.23 (109.44)	157.08 (174.59)	65.00 (38.12)	73.07 (69.55)	114.46 (107.77)	115.95 (138.58)	99.68 (97.70)	127.07 (143.60)
Trauma Admissions	111.75 (120.40)	170.78 (186.34)	152.65 (122.03)	178.30 (165.28)	165.19 (129.86)	188.50 (173.41)	152.54 (122.54)	190.61 (162.77)
Substance Abuse Admissions	53.53 (46.33)	96.26 (92.90)	68.13 (91.89)	46.63 (22.07)	72.88 (78.83)	63.56 (48.68)	57.97 (68.76)	63.00 (45.80)
Neurosurgery Admissions	104.60 (61.36)	111.56 (72.35)	126.42 (155.40)	151.42 (278.39)	123.34 (134.78)	143.17 (241.60)	117.57 (122.43)	144.81 (213.47)

Standard deviation in parentheses

Table 3. Fixed Effect Analysis of Number of Admissions, by diagnosis

	Psychiatric	Trauma	Substance Abuse	Neurosurgery
Top 25th percent of exposure (Reduction of more than 786 system-level or 416 hospital admissions)				
Exposure	-39.29*	-15.00	-59.46***	10.86
	(22.70)	(13.05)	(14.40)	(16.13)
1998	7.889	0.766	6.176	6.405
	(14.45)	(8.931)	(9.458)	(11.58)
2005	64.01***	62.33***	48.61***	30.76**
	(15.80)	(9.716)	(10.00)	(12.83)
2006	59.82***	65.98***	46.38***	26.64**
	(15.95)	(9.775)	(10.00)	(12.97)
2007	30.11*	36.57***	28.15***	-5.363
	(15.95)	(9.919)	(10.10)	(12.97)
Constant	101.7***	131.9***	52.04***	109.7***
	(10.39)	(6.387)	(6.701)	(8.231)
Top 50th percent of exposure (Reduction of more than 665 system-level or 210 hospital admissions)				
Exposure	-50.66**	-7.437	-51.80***	4.372
	(19.96)	(11.85)	(12.67)	(14.98)
1998	8.007	0.766	6.176	6.405
	(14.29)	(8.953)	(9.469)	(11.60)
2005	72.11***	60.79***	52.84***	32.44**
	(16.21)	(10.02)	(10.42)	(13.43)
2006	65.40***	64.11***	47.66***	28.59**
	(15.95)	(9.878)	(10.14)	(13.19)
2007	35.69**	34.82***	29.42***	-3.407
	(15.95)	(10.13)	(10.23)	(13.19)
Constant	101.6***	132.0***	52.00***	109.6***
	(10.27)	(6.405)	(6.708)	(8.242)
Top 75th percent of exposure (Reduction of more than 263 system-level or 87 hospital admissions)				
Exposure	-18.47	1.894	-38.70***	18.04
	(19.04)	(11.45)	(12.10)	(14.85)
1998	7.871	0.766	6.176	6.405
	(14.55)	(8.962)	(9.682)	(11.54)
2005	63.90***	56.98***	55.07***	23.37
	(17.77)	(10.85)	(11.56)	(14.72)
2006	58.41***	60.67***	50.63***	20.45
	(17.28)	(10.59)	(11.20)	(14.26)
2007	28.70*	31.10***	32.44***	-11.55
	(17.28)	(10.88)	(11.31)	(14.26)
Constant	101.7***	131.8***	51.96***	109.8***
Hospital-Years	196	239	172	183

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Control for Hospital Fixed Effects; Sample 1997-1998 & 2005-2007

Table 4. Negative Binomial Regression Estimates of the Market-Level Effect of Entry on Admissions, by Diagnosis

	Psychiatric	Trauma	Substance Abuse	Neurosurgery
Post-Entry	0.742***	0.315***	0.683***	0.123
	(0.214)	(0.0794)	(0.215)	(0.119)
Arizona*Post-Entry	-0.386	-0.00218	-0.217	-0.0711
	(0.260)	(0.0968)	(0.260)	(0.159)
Constant	6.366***	5.461***	5.492***	5.105***
	(0.240)	(0.0922)	(0.298)	(0.136)
Observations	196	239	172	183

Robust standard errors with hospital level clustering in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Control for Hospital Fixed Effects; Sample 1997-1998 & 2005-2007

Table 5. Marginal Effects of Negative Binomial Regression of Number of Admissions, by Exposure and Diagnosis

Variables	**Psychiatric Services**		**Trauma Care**		**Substance Abuse**	
		Endogenous		*Endogenous*		*Endogenous*
Top 25th percent of exposure (Reduction of more than 786 system-level or 416 hospital admissions)						
	-43.72*	-38.24	-13.92	-1.380	-24.31	-24.70
	(25.08)	(24.85)	(8.700)	(9.010)	(19.18)	(19.95)
Top 50th percent of exposure (Reduction of more than 665 system-level or 210 hospital admissions)						
	-111.2***	-102.5***	-32.08**	-18.35	-44.04**	-39.03*
	(36.67)	(35.98)	(14.41)	(12.01)	(21.97)	(23.48)
Top 75th percent of exposure (Reduction of more than 263 system-level or 87 hospital admissions)						
	-91.59***	-98.30***	-12.83	4.457	-32.27*	-27.05
	(31.29)	(33.51)	(13.68)	(11.93)	(18.19)	(17.02)

Controls for Hospital Fixed Effects, Year, % Emergency Admissions and other hospital characteristics.
Robust standard errors with hospital clustering in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 6. Effect of Entry on Market Share, by Exposure Level and Diagnosis

Exposure to Entry	Psychiatric Services		Trauma Care		Drug / Substance Abuse	
		Endogenous		*Endogenous*		*Endogenous*
Top 25th percentile	-0.180***	-0.176***	-0.157***	-0.110***	-1.277***	-1.291***
	(0.0351)	(0.0357)	(0.0250)	(0.0270)	(0.0519)	(0.0530)
Residual		0.0281		0.220***		-0.282
		(0.0563)		(0.0525)		(0.197)
Top 50th percentile	-0.337***	-0.343***	-0.117***	-0.0454*	-0.938***	-0.905***
	(0.0241)	(0.0260)	(0.0233)	(0.0252)	(0.0439)	(0.0441)
Residual		-0.0311		0.355***		0.648***
		(0.0591)		(0.0552)		(0.129)
Top 75th percentile	-0.244***	-0.0273	-0.0377	0.310***	-0.682***	-0.631***
	(0.0231)	(0.0318)	(0.0245)	(0.0342)	(0.0424)	(0.0423)
Residual		0.969***		1.154***		1.270***
		(0.0970)		(0.0813)		(0.159)

Controls for Drive Time interacted with: Hospital Fixed Effects and Patient characteristics in Table 1; Year, and whether the hospital reported partial year of data.
Robust standard errors with patient clustering are in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 7. Analysis of Neurosurgery Admissions

	Number of Admissions (Marginal Effects from Negative Binomial)		Probability of Admission (Market Share from Conditional Logit Model)	
		Endogenous		*Endogenous*
Top 25th percentile	-43.36** (20.87)	-40.98** (18.47)	0.123*** (0.0333)	0.112*** (0.0335)
Top 50th percentile of exposure				
	Number of Admissions		**Probability of Admission**	
		Endogenous		*Endogenous*
Top 50th percentile	-40.26** (17.82)	-40.16*** (15.35)	0.0963*** (0.0305)	0.133*** (0.0315)
Top 75th percentile of exposure				
	Number of Admissions		**Probability of Admission**	
		Endogenous		*Endogenous*
Top 75th percentile	-10.92 (18.40)	-24.56 (22.20)	0.226*** (0.0351)	0.228*** (0.0352)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

NOTE: there are no hospital systems in Tuscon are in the top 25% of exposure

Table A1. Results of Conditional Logit Analysis Cardiac Admissions

Market:	Phoenix		Tucson		Denver	
Service:	Surgical	Medical	Surgical	Medical	Surgical	Medical
Teaching Hospital	0.483***	1.101***	-1.298***	-1.038***	0.557**	-0.0962
	(0.0334)	(0.0293)	(0.0548)	(0.0447)	(0.268)	(0.283)
Cardiac Catheterization	0.488***	-0.483***	0.468*	0.118**	-1.774***	-0.325***
	(0.0367)	(0.0216)	(0.263)	(0.0574)	(0.0921)	(0.0497)
Open-heart Surgery	0.839***	0.823***	1.097***	1.080***	1.890***	0.572***
	(0.0250)	(0.0170)	(0.0940)	(0.0503)	(0.0869)	(0.0476)
Ln(Drive Time)	-1.063***	-1.500***	-0.0256	-0.504***	-1.121***	-0.997***
	(0.0331)	(0.0231)	(0.0788)	(0.0441)	(0.0993)	(0.0762)
Ln(Drive Time) interacted with:						
Emergency Admission	-0.941***	-0.824***	-0.875***	-0.517***	-0.425***	0.0167
	(0.0125)	(0.00946)	(0.0295)	(0.0178)	(0.0420)	(0.0299)
Median Income	-1.14e-05***	-9.68e-06***	-2.34e-05***	-2.70e-05***	-2.31e-05***	-3.21e-05***
	(4.86e-07)	(3.74e-07)	(1.25e-06)	(8.50e-07)	(1.56e-06)	(1.31e-06)
Age 50-74	-0.184***	-0.166***	-0.0715	-0.0765***	-0.319***	-0.167***
	(0.0175)	(0.0131)	(0.0451)	(0.0263)	(0.0460)	(0.0388)
Age >=75	-0.314***	-0.323***	-0.192***	-0.155***	-0.466***	-0.216***
	(0.0194)	(0.0137)	(0.0495)	(0.0268)	(0.0586)	(0.0435)
# Procedures	-0.0418***	0.0973***	-0.279***	-0.0632***	0.175***	0.494***
	(0.00322)	(0.00249)	(0.0340)	(0.0201)	(0.0396)	(0.0336)
# Diagnoses	0.0185***	0.0167***	0.0320***	0.162***	-0.0168**	0.100***
	(0.00253)	(0.00191)	(0.00798)	(0.00461)	(0.00700)	(0.00585)
HMO Payer	-0.0688***	0.00490	-0.0168***	0.0134***	0.00784	-0.0323***
	(0.0122)	(0.00942)	(0.00636)	(0.00351)	(0.00806)	(0.00619)

Table A1. Results of Conditional Logit Analysis Cardiac Admissions (continued)

Market:	Phoenix		Tuscon		Denver	
Service:	**Surgical**	**Medical**	**Surgical**	**Medical**	**Surgical**	**Medical**
Patient Diagnosis-Hospital Service Offerings Interactions						
Cardiac Catheterization	1.049***		3.343***		-0.127*	
	(0.0520)		(1.039)		(0.0749)	
Stent*Open Heart Surgery	0.611***		0.884***		0.397***	
	(0.0240)		(0.0733)		(0.147)	
Open Heart Surgery	1.830***		0.961***		0.0753	
	(0.0336)		(0.0847)		(0.0613)	
Patient Diagnosis-System Service Offerings Interactions						
Cardiac Catheterization	0.0265***		0.0225*		-0.0626***	
	(0.00457)		(0.0132)		(0.0104)	
Stent*Open Heart Surgery	-0.0317***		0.0374**		-0.0838***	
	(0.00492)		(0.0154)		(0.0233)	
Open Heart Surgery	0.0141***		-0.341***		-0.00977	
	(0.00545)		(0.0191)		(0.0216)	
Hospital Fixed Effects * Ln(Drive Time)						
Hospital 2	-0.0102*	-0.0646***	-0.0243***	-0.194***	-0.375***	-0.273***
	(0.00605)	(0.00554)	(0.00645)	(0.00553)	(0.0146)	(0.0117)
Hospital 3	-0.102***	-0.0529***	-0.0210	0.0254	-0.218***	-0.393***
	(0.00862)	(0.00691)	(0.0266)	(0.0161)	(0.0145)	(0.0164)
Hospital 4	0.221***	0.0211***	-1.625***	-1.462***	-0.0466***	-0.186***
	(0.00607)	(0.00543)	(0.0799)	(0.0830)	(0.0121)	(0.0120)
Hospital 5	-0.281***	0.103***	-0.240***	-0.431***	-0.193***	-0.254***
	(0.0193)	(0.00801)	(0.00788)	(0.0233)	(0.0138)	(0.0133)
Hospital 6	0.104***	0.0244***	-0.189***	-0.145***	0.0750***	-0.935***
	(0.00624)	(0.00621)	(0.00741)	(0.0158)	(0.00941)	(0.0301)
Hospital 7	-0.225***	-0.164***	-0.0919***	-0.192***	-0.338***	0.0215***
	(0.00956)	(0.00793)	(0.0307)	(0.0195)	(0.0152)	(0.00701)

Table A1. Results of Conditional Logit Analysis Cardiac Admissions (continued)

Market:	Phoenix		Tuscon		Denver	
Service:	**Surgical**	**Medical**	**Surgical**	**Medical**	**Surgical**	**Medical**
Hospital Fixed Effects * Ln(Drive Time)						
Hospital 8	-0.0756***	-0.116***	0.272***	-0.208***	-0.221***	-0.401***
	(0.00790)	(0.00658)	(0.0154)	(0.00555)	(0.0140)	(0.0151)
Hospital 9	-0.310***	-0.0319***	-0.112***	-0.00896**	-0.216***	-0.286***
	(0.0108)	(0.00676)	(0.00614)	(0.00454)	(0.0124)	(0.0128)
Hospital 10	-0.00463	0.0541***		-0.131***	-0.287***	-0.264***
	(0.00738)	(0.0116)		(0.0192)	(0.0139)	(0.0119)
Hospital 11	0.0363***	-0.206***		0.194***	-0.259***	-0.318***
	(0.00854)	(0.00727)		(0.0140)	(0.0619)	(0.0133)
Hospital 12	0.0687***	-0.181***		-0.0967***	-0.327***	-0.164**
	(0.0143)	(0.00730)		(0.00501)	(0.0167)	(0.0664)
Hospital 13	-0.261***	-0.295***		-0.308***	0.0866***	-0.346***
	(0.00820)	(0.0152)		(0.0220)	(0.0109)	(0.0144)
Hospital 14	0.222***	-0.0570***			-0.400***	0.0753***
	(0.00693)	(0.00813)			(0.0185)	(0.00965)
Hospital 15	0.117***	-0.153***			-0.830***	-0.267***
	(0.0103)	(0.0109)			(0.0434)	(0.0138)
Hospital 16	-0.122***	-0.315***				-0.544***
	(0.00747)	(0.00712)				(0.0203)
Hospital 17	-0.151***	0.0176**				
	(0.0160)	(0.00683)				
Hospital 18	-0.0162	-0.154***				
	(0.0121)	(0.00997)				
Hospital 19	0.125***	-0.115***				
	(0.00777)	(0.00609)				
Hospital 20	-0.243***	-0.328***				
	(0.0124)	(0.0128)				

Table A1. Results of Conditional Logit Analysis Cardiac Admissions (continued)

Market:	Phoenix		Tuscon		Denver	
Service:	Surgical	Medical	Surgical	Medical	Surgical	Medical
Hospital Fixed Effects * Ln(Drive Time)						
Hospital 21	0.0110	-0.00662				
	(0.00733)	(0.00880)				
Hospital 22	-0.287***	-0.350***				
	(0.0162)	(0.00853)				
Hospital 23	-0.307***	-0.438***				
	(0.0174)	(0.0111)				
Hospital 24	-0.256***	-0.224***				
	(0.00807)	(0.00731)				
Hospital 25	-0.0553***	-0.224***				
	(0.00707)	(0.0105)				
Hospital 26	0.0194***	-0.157***				
	(0.00667)	(0.0103)				
Hospital 27	-0.530***	-0.250***				
	(0.0324)	(0.00655)				
Hospital 28	-0.00371	-0.0398***				
	(0.00668)	(0.00573)				
Hospital 29	-0.309***	0.00656				
	(0.0180)	(0.00519)				
Hospital 30		-0.313***				
		(0.00990)				
Hospital 31		0.00817				
		(0.00548)				
Hospital 32		-0.112***				
		(0.0102)				
Observations	2234621	2376325	195349	415210	332565	341968

Standard errors in parentheses
** p<0.01, ** p<0.05, * p<0.1