Entry and Competition in Markets for Specific Hospital Services

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Abstract: Competition occurs in hospital markets at the firm level, but hospitals compete at the product level as well. We consider hospitals as multiproduct firms and analyze hospitals' decisions to supply specific medical services. We employ the approach developed by Bresnahan and Reiss (1991) to analyze forty-six commonly provided services. We use data from 141 geographically isolated MSA's and 78 large population counties to study entry and competition for thirty-one services that are provided by fewer than half of all hospitals. We use data from all counties that have at least one hospital and a population of less than one million to analyze entry and competition for fifteen services that are provided by a majority of hospitals. Whether or not to offer the first group of services in some sense constitutes more of a strategic decision for hospitals than services that are typically offered by most hospitals. Among the strategically provided services, there are eight services that tend to approach a competitive equilibrium after the third or fourth hospital enters the market. Among commonly provided services, competition increases dramatically with the entry of a second hospital provider, and a competitive equilibrium is reached after the third or fourth entrant for most of these services. This result accords with Abraham, Gaynor, and Vogt's (2007) findings for entry into small to medium-sized hospital markets.

I. Introduction

Over the past two decades the hospital industry has been experiencing extensive consolidation, especially during the second half of the1990's. Approximately 1,000 mergers occurred between 1986 and 2000 and a significant number of hospital closures occurred during that period.[1] The number of general hospitals dropped from 6035 in 1980 to 4862 in 2000.[2] At the same time, there has been a notable increase in the number of private facilities that specialize in areas such as cardiac care, orthopedics, and women's medicine. According to a 2003 General Accounting Office (GAO) report, the number of private specialty hospitals in the U.S. had tripled from the 29 that existed in 1990. As of 2006, when a moratorium was lifted on new specialty hospitals, the number had grown to 130.[3] The wave of hospital consolidations, hospital closures, and the surge of specialty hospitals have altered local market structure and the pattern of competition for hospital services.

The hospital industry is different from many other industries in that its markets are characterized by heterogeneous products, asymmetric information, extensive government regulation, and the presence of nonprofit firms. Any of these characteristics may affect the nature of competition in the industry and thus affect social welfare. We are particularly interested in the multi-product aspect of hospitals. Hospitals generally provide a range of medical services, although there is wide variety in the bundle of services chosen by different hospitals. There are both demand side and supply side reasons for such bundling. For example, obstetrical, ultrasound, labor/delivery, and birth

[1] Gloria Bazzoli : http://www.ahrq.gov/news/ulp/hospital/bazzolitxt.htm
[2] Source: http://www.cms.hhs.gov/charts/healthcaresystem/chapter2.asp
[3] "Doctor-Owned Specialty Hospitals Get a New Lease on Life," *Wall Street Journal*, 8/29/06, p. B1.

room services are demand complements that expectant mothers might value being offered by a single provider. Likewise, cost complementarities across services such as cardiology, cardiac catheterization lab, and intensive cardiac services are easy to imagine.

Demand for various medical services combined with the multiproduct cost structure of producing different combinations of services thus interact to determine the specific bundles offered by hospitals. In small isolated geographic markets, economies of scale and scope usually make it efficient for one local hospital to supply the entire set of medical services provided in the market.[4] In markets large enough to support multiple providers, however, each hospital must strategically decide which specific health service markets to enter.[5] Competition occurs in hospital markets at the firm level, but hospitals compete at the product level as well.[6] Indeed, economies of scale in a particular service or subset of services may make it economical to unbundle those services and provide them in stand-alone specialty hospitals.[7]

In this paper we consider hospitals as multiproduct firms and analyze hospital entry into specific medical services. We use the approach developed by Bresnahan and Reiss (1991) and analyze forty-six commonly provided services. We separate hospital

[4] Abraham, Gaynor, and Vogt (2007) analyze entry and competition among hospitals in just such small, geographically isolated markets. They consider only full service hospitals, and thus treat hospitals as single-product firms.

[5] For example, Chernew, Gowrisankaran, and Fendrick (2002) analyze hospitals' decisions to enter the market for coronary artery bypass graft surgery. They assume that hospitals will choose to enter and provide that service only if they receive sufficient returns. Horwitz and Nichols (2007) categorize specific hospital services according to profitability, and see whether ownership type influences the decision to provide a particular service. Ciliberto (2006) investigates whether a hospital's organizational form affects the adoption rate of specific medical services.

[6] Krishnan (2001) studies price effects of hospital mergers and acquisitions at the level of the individual diagnosis related group (DRG). He finds that mergers result in increased prices for all DRGs, but that price increases are greater in DRGs where a hospital gained substantial market share.

[7] The 2003 GAO report (p. 5) found that specialty hospitals tended to treat more patients than did surrounding general hospitals for that specific type of medical care. Barro, Huckman, and Kessler (2006) find that markets experiencing entry by cardiac specialty hospitals have lower spending for cardiac care without significantly worse clinical outcomes.

services into two groups based on the number of hospitals providing these services. The first group contains thirty-one specialties such as open heart surgery, sports medicine, and neuro-surgery that are provided by less than half of U.S. hospitals, and the second group contains fifteen services such as emergency rooms that are provided by a majority of all hospitals. Since fewer than half of all hospitals provide the first group of services, whether or not to offer these services in some sense constitutes more of a strategic decision for hospitals than services that are typically offered by most hospitals.

We use data from 141 geographically isolated MSA's and also from 78 geographically isolated large population counties to analyze entry and competition for the first group of thirty-one strategically provided services. For the second group of commonly provided services, we consider all counties that have at least one hospital and a population of less than one million as potential markets, a total of 2073 counties. Market size, as measured by population, has a significant effect on entry decisions of hospitals. The z values for most services are quite large, which supports the hypothesis that the equilibrium number of hospitals providing a specific medical service in a market is mainly determined by the population size. The regression results validate the application of the population threshold method in the hospital industry when analyzing firms' competitive behavior.

Among the strategically provided services, there are eight services that tend to approach a competitive equilibrium after the third or fourth hospital enters the market. Four of these, Intensive Neonatal, Women's Center, Lithotripsy, and Sports Medicine, are services categorized by Horwitz and Nichols (2007) as being profitable for a hospital

to offer, while three others, Neuro-Surgical, Neurological, and Histopathology, are not classified. Only alcohol inpatient among the eight is classified as unprofitable by Horwitz and Nichols. Among commonly provided services, the results show that competition increases dramatically with the entry of a second hospital provider for these services, indicating that essential services like emergency rooms will be included in a hospital's product mix no matter how small the market. After the third or fourth entrant a competitive equilibrium is reached for most of these services. The observed patterns seem to indicate that strategic behavior may occur at the hospital level and not at the specific service level for these services that are offered by a majority of hospitals. This result accords with Abraham, Gaynor, and Vogt's (2007) findings for entry into small to medium-sized hospital markets.

II. Empirical Studies of Hospital Markets

Empirical studies of hospital markets fall generally into the following categories: (1) competition and price studies, which examine the effect of competition among hospitals on pricing behavior, where competition is usually measured by a Herfindahl-Hirschman index (HHI) and prices are measured as average hospital charges or charges of a particular service; (2) studies of the effect of government regulation on hospital entry; most of these studies are related to the effect of one particular government regulation—Certificate of Need; (3) insurance and hospital performance studies, which mainly examine the impact of managed care organizations (MCOs) on hospital performance; (4) ownership and competition studies, which investigate whether not-for-profit hospitals behave differently than for-profit hospitals; and (5) studies of hospital entry and

competition, which analyze changes in entry conditions when market structure and demographics change.

Competition and Price

There have been a large number of studies relevant to hospital competition and performance.[8] The majority adopt a structure-conduct-performance (SCP) regression approach, where some measure of hospital price is regressed on a measure of market concentration, and find a positive association between market concentration and price or price-cost margins.[9] These studies are subject to the criticism that prices and price-cost margins are poorly measured. The prices that hospitals charge are not usually what patients pay because (1) the vast majority of patients are enrolled in some form of managed care plan (Quinn (1998), Jensen, et al., (1997)), and (2) different insurance companies, such as managed care organizations, have different bargaining power over prices of hospital services.

To summarize this literature, there is some evidence that supports the medical arms race hypothesis in the 1960's and 1970's, which indicates that hospitals competed on non-price dimensions. For example, hospitals may have competed for physicians by offering the best technologies. Consequently, higher market competition (lower market concentration) was associated with higher prices. More recent studies provide evidence that U.S. hospitals have become more responsive to price competition since the late 1980s when managed care organizations including PPOs and HMOs experienced a rapid

[8] See, for example, Davis (1971), Farley (1985), Kopit and McCann (1988), Noether (1988), Staten, et al. (1988), McManis (1990), Gruber (1994), Melnick, et al. (1992), Dranove, et al. (1993), Simpson and Shin (1998), Brooks, et al. (1997), Connor, et al. (1998), Lynk (1995), Lynk and Newmann (1999), Dranove and Ludwick (1999), and Krishnan (2001). Gaynor and Vogt (2000) review this literature.
[9] Except for Noether (1988), Lynk (1995), and Lynk and Newmann (1999).

growth. The evidence indicates prices measured at both the hospital level and the DRG level are lower in less concentrated markets after controlling for hospital and market characteristics.

Certificate of Need Regulations

One state regulation particularly relevant to the study of entry into hospital markets is Certificate of Need (CON). These programs are established by state laws and require health care service providers to obtain a certificate from the state government before they initiate, upgrade or modernize, or relocate or acquire health facilities, services, or equipment. Covered facilities, services, and equipment vary from state to state and there is considerable variation in how the programs are administered. However, virtually all CON regulations affect new firms planning to enter the industry.

The majority of states (31 states) enacted CON laws after Congress passed the Federal Health Planning and Resources Development Act in 1974, which provided federal funds for state health planning and development agencies. In 1976, Congress passed an amendment to the Social Security Act that required states to pass CON acts, and as a result all but Louisiana had a CON program by 1980 (Louisiana passed CON legislation in 1991). This requirement was eliminated in 1983, and in 1987, Congress stopped funding local health planning agencies. Currently, only 36 states and the District of Columbia continue to regulate the allocation of health care resources through CON, or a similar program under a different name. The intended effects of the program are to regulate duplicative or unneeded hospital services, thus the costs of care have been examined by a number of studies.

The majority of studies provide evidence that CON regulations do not successfully control hospitals costs.[10] In addition, some researchers find that the regulations have had a significant impact on entry of new firms and the expansion of capacity.[11] There is also some evidence that CON regulations only deter the entry of small hospitals which results in a decrease in the number of small hospitals.[12]

Managed Care and Hospital Competition

The two most common types of Managed Care Organizations are preferred provider organizations (PPOs) and health maintenance organizations (HMOs). PPOs work by contracting with a network of providers that agree to offer services at lower than normal hospital charges. HMOs have exclusive provider networks and provide health care through a group of doctors, medical personnel, and facilities that work directly with the HMOs.

Managed Care Organizations have grown very rapidly since the early 1980s, and total enrollment in HMOs and PPOs reached approximately 175 million by 2005. The rapid growth of enrollment in managed care during the late 1980s and 1990s has had a dramatic impact on the health care industry, especially the market behaviors of hospitals. Glied (2001) and Gaynor and Vogt (2000) provide thorough reviews of HMO-related studies.

The increase in the number of hospital mergers and consolidations accompanied by the growth of managed care enrollment in 1980s and 1990s alone has attracted a large number of studies, including Dranove, Simon, and White (2002) and Town, Wholey,

[10] See Sloan and Steinwald (1980), Sloan (1981), and Antel, Ohsfeldt, and Becker (1995).
[11] For example, Ford and Kaserman (1993), Caudill, Ford, and Kaserman (1995), and Conover and Sloan (1998).
[12] Conover and Sloan (1998).

Feldman, and Burns (2005). In addition to research on the impact of managed care on hospitals, several studies have examined how the provision of particular hospital services is affected by managed care penetration in a market, including Baker and Brown (1997), Baker (2000), and Baker and Phibbs (2002). Other studies directly investigate the impact of managed care on hospital financial performance, such as Cutler and Sheiner (1997), McCue, Clement, and Luke (1999), Younis, Rivers, and Fottler (2005), and Feldman and Wholey (2001). Finally, Ciliberto (2006) looks at hospital organizational form and the penetration of Managed Care Organizations.

Not-for-Profits vs. For-Profits

The analysis of competition in the hospital industry is complicated by the presence of a large number of not-for-profit firms—approximately 80 percent of U.S. hospitals are not-for-profit. It has been argued that the objective functions are different for hospitals with different ownership.[13] Pauley (1987) described institutional differences between not-for-profit and for-profit firms: (1) not-for-profit firms receive initial equity from donations instead of from financial markets; (2) not-for-profit firms are not permitted to distribute their profit; and (3) the individual owners cannot receive the proceeds from the selling or liquidation of not-for-profit hospitals. After reviewing studies in the 1970s and 1980s, however, Pauley concluded that "the major message from theoretical or empirical work on not-for-profit health care firms is that such ownership differences turn out to be much less important than they might seem." In contrast, Newhouse (1970) pointed out that prestige is a "prominent" variable in the utility functions for not-for-profit hospitals and prestige can be affected by the size of the

[13] See Newhouse (1970), Lakdawalla and Philipson (1998), Steinberg (1986), and Smith, Clement, and Wheeler (1995).

institution and the quality of product. He further argued that low efficiency and quality are associated with not-for-profit hospitals and so not-for-profit and for-profit hospitals may respond differently to market competition. Empirical findings in the literature are mixed, however, a majority of studies support Pauley's argument.[14]

Entry and Competition

In a series of papers Bresnahan and Reiss (1987, 1990, 1991) presented an empirical model that can be used to examine how the entry of a firm affects market competition and whether entry conditions vary across different industries if financial data on prices, profits, and costs in these industries are not available. They argue that the number of firms in a market is mainly determined by the demand or size of the market, which can be proxied by its population. Population in a market must reach an entry threshold value in order for a monopoly to make enough variable profits to cover the firm's fixed costs; similarly, an entry threshold population exists for duopoly and oligopoly. The ratio of the entry threshold population for duopoly to that for monopoly has implications about effects on competition by the second entrant in a market. In addition, the presence of economies of scale can be inferred from the size of the threshold population needed to support a monopoly.

In their 1987 paper Bresnahan and Reiss examine entry conditions of monopoly and duopoly for six "professional" industries (e.g., dentists and veterinarians) and seven "retail" industries (e.g. cooling contractors and plumbers). Their findings suggest that

[14] Lynk (1995) and Lynk and Neumann (1999) find that the pricing behavior of not-for-profit hospitals differs from that of for-profit hospitals. Lynk's results were challenged by Dranove and Ludwick (1999), Keeler, Melnick, and Zwanziger (1999), and Simpson and Shin (1998). Norton and Staiger (1994) find no differences in provision of services to uninsured patients. Banks, Paterson, and Wendel (1997) find that not-for-profits are more likely to provide uncompensated services. Sloan, Picone, Taylor, and Chou (1998) find no differences in cost and quality of care. Cutler and Horwitz (2000), Duggan (2002), and Horwitz (2005) find that not-for-profits and for-profits influence one another's behavior when each are present in the same geographic market.

entry conditions are different among these industries-- the entrant affects market competition differently across industries. Sunk costs, economies of scale, and toughness of competition between the incumbent and entrant mainly explain why some markets are more concentrated than others. Their 1990 paper examines the market for new automobile dealers in 149 geographically isolated towns in the U.S. They find that the number of automobile dealers is mainly determined by population size in a market, and that monopoly car dealers do not behave strategically to deter entry of a second firm and the entry of a second dealer does not lower variable profit by much. Their 1991 paper analyzes five retail and professional services in the western United States—doctors, dentists, druggists, plumbers, and tire dealers—where firms only provide a narrow range of services. They find that entry in all the five retail and professional industries increases market competition, and that the impact decreases with the number of incumbents. Importantly, the competitive effects of entry on competition occur in duopoly and triopoly markets—the second and third entrant has the most significant impact, and the markets reach a competitive condition once there are two or three firms.

Dranove, Shanley, and Simon (1992) modified Bresnahan and Reiss's model to test the medical arms race hypothesis. They looked at 11 high-tech hospital services that are identified using 1983 data from the California Office of Statewide Health Planning. This paper is unique in that it treats hospitals as multiproduct firms when examining the effect of hospital entry on competition. They find little support for the MAR hypothesis, but instead find that the supply of services is determined largely by the extent of the market. They also looked at patterns of entry into hospital services as a function of demand. Their findings are broadly consistent with those identified by Bresnahan and

Reiss. Their study is limited in that: (1) there are only 87 markets in their sample, which could be problematic when using an ordered probit model because there are only a few observations in each category to determine threshold parameters; and (2) they use state level data for only California, hence the results might not be applicable nationally.

More recently, in a paper directly related to the topic of this paper, Abraham, Gaynor, and Vogt (2007) extend Bresnahan and Reiss's entry model by using quantity information on a sample of U.S. hospitals. In their analysis, hospitals are treated as a single product firm which sells hospital services, thus the number of firms is defined as the number of hospitals. Their hospital data come from the 1990 American Hospital Association annual survey, which excludes military hospitals and hospitals with fewer than 50 beds. The potential markets for hospitals are defined as cities and census designated places with population of at least 5,000 and at least 50 miles away from a city with a population of at least 100,000. Also, potential markets that are within 15 miles of another potential market are eliminated. There are a total of 613 markets with 490 hospitals identified in the continental U.S.[15] They find that the entry of the second and third hospitals into a local market generally leads to an increase in the number of patients seen by each hospital in the market and a decrease in hospital average profits as a fraction of fixed costs.[16] The fourth entrant does not have much effect on per firm demand and average profits.

III. Modeling Entry of Hospitals into Specific Health Services

Bresnahan and Reiss (BR) (1987, 1990, 1991) have developed an empirical model for studying entry. Two previous papers, Dranove, Shanley, and Simon (DSS) (1992)

[15] Abraham, Gaynor, and Vogt point out that by excluding big cities, they under-sample large hospitals.
[16] Abraham, Gaynor, and Vogt incorporate quantity data in their model, which allows them to separate changes in fixed cost associated with entry from changes in the toughness of competition.

and Abraham, Gaynor, and Vogt (AGV) (2007) have used this approach to study entry in the hospital industry. DSS treat hospitals as multi-product firms, and use 1983 data to study eleven specific high-tech health services for the state of California. AGV treat hospitals as single-product firms and use 1990 data to analyze hospital entry into smaller geographic markets across the U.S. Since we are analyzing hospital entry into specific health services using a national sample, the BR model of entry is well suited.

The BR model predicts the size of a market that can support zero, one, two, or more firms. There exists a population level below which no firm will enter and above which the market will have at least one firm, which BR call the entry threshold for monopoly, S_M. Similarly, S_D, the size of the market at which a second firm can profitably enter, is defined as the entry threshold for duopoly. The monopoly threshold tells us something about the degree of economies of scale while the ratio, S_D/S_M, indicates the importance of strategic deterrence by the incumbent monopolist under certain economic assumptions.

The empirical model below closely follows BR, DSS, and AGV. We assume that the number of hospitals observed in the market is in long-run equilibrium.[17] We treat hospitals as multiproduct firms, and analyze forty-six commonly provided services, which are listed in Table 1. Hospitals must decide which specific services to offer (e.g., MRI, Dialysis, Sports Medicine), although some services are likely to be offered together (e.g., Ultrasound and Labor/Delivery). The strongest correlation between any two services is 0.8 between Labor/Delivery and Birth Room, but for most services the

[17] This assumption is reasonable given the wave of hospital consolidations and hospital closures during the 1990s.

correlation coefficients are smaller than 0.4. In addition, almost all studies of hospital cost functions treat hospitals as multiproduct firms.[18]

Specific health care services offered by hospitals are the outputs in this study. Total demand for a particular service in a market is given by: $Q = d(Z, M, P)\, S(Y)$, where $d(Z, M, P)$ expresses the demand function of a representative consumer and $S(Y)$ denotes the number of consumers in the market.[19] P is the price of the medical service, and M is a vector of variables that may affect consumer demand such as the level of managed care penetration, government regulation, and hospital ownership. Both Z and Y denote demographic variables affecting market demand for hospital services, however, Z is a vector of variables that affect individual consumer demand while Y is a vector of variables that affect the level of total demand, keeping other variables constant. For example, income per capita affects the demand of individual consumers and is part of Z, while the proportion of older population in a market is included in Y. This demand specification presumes that if the number of consumers doubles, total market demand will double at any given price, and that consumer tastes do not change if a consumer moves to a different size market with the same Z, M and P.

[18] Fournier and Mitchell (1992) estimated a generalized translog multiproduct cost function to examine the effect of market structure and market competition. Five hospital outputs were identified by the authors including inpatient admission, outpatient, maternity, emergency, and surgery. They found some evidence that hospital costs increase with the level of competition. Also their findings indicate that hospitals experience economies of scale and scope in providing these services. Li and Rosenman (2001) estimated a long-run cost function with multiple outputs, outpatient and inpatient services. They found hospitals experience significant economies of scale, but limited economies of scope. The limitation of these studies is that the hospital services (outputs) are broadly defined. Thus it is not possible to determine whether hospitals experience economies of scale in providing a specific service such as cardiology.

[19] We allow other variables to affect S(Y) in our regression analysis, including the number of people who commute a long distance to work, distance to the next market, and population in surrounding areas.

A hospital that offers a particular medical service incurs fixed cost F(W), marginal cost MC(q, W), and average variable cost AVC(q, W), where W represents exogenous variables affecting costs and q is the output. We assume a U-shaped average cost curve, declining initially because of fixed costs and rising later because of increasing marginal costs. Numerous empirical studies find economies of scale in hospitals (e.g. Dranove (1998), Li and Rosenman (2001), Wilson and Carey (2004)), so it is plausible to assume U-shaped average cost for a particular service.[20] The relatively small correlation coefficients between most specific services indicate that *strong* cost complementarities are not the norm across specific hospital services

In order for a monopoly hospital to provide a particular service, it has to at least earn zero economic profit, which implies,

$$\Pi_1(S_1) = [P_1 - AVC(q_1, W)]d(Z, M, P_1)S_1 - F = 0 \qquad (1)$$

After some simple algebra

$$S_1 = \frac{F}{[P_1 - AVC(q_1, W)]d(Z, M, P_1)} \qquad (2)$$

where S_1 is the threshold population size in a market necessary to support at least one provider. It equals the ratio of fixed cost to variable profits per customer. The larger are fixed costs or the lower are variable profits, the more people are needed in a market to support the first entrant.

[20] There are no studies of economies of scale in individual hospital services (of which we are aware) simply because it is very difficult to identify the cost of providing any special service. The cost concept we are describing here is actually the average incremental cost curve (AIC). See Baumol, Panzar, and Willig (1982) for a detailed discussion on costs of multiproduct firms.

As population in a market grows, at some point the market will support a second firm, and then a third firm, etc. So the Nth entrant earns profits of

$$\Pi_N(S_N) = [P_N - AVC(q_N, W)]d(Z, M, P_n)\frac{S_N}{N} - F_N \qquad (3)$$

The breakeven condition $\Pi_N = 0$ gives the breakeven level of demand (threshold population) for each of the N hospitals (N is the number of hospitals in an oligopoly market). Formally,

$$s_N = \frac{S_N}{N} = \frac{F_N}{[P_N - AVC(q_N, W)]d_N(Z, M, P_N)} \qquad (4)$$

where S_N is the total population in a market and s_N is the population needed to support one of N hospitals; P_N is the price of the medical service; q_N is the hospital output; and d_N is the demand of a representative consumer. As in equation (2), it equals the ratio of fixed costs to equilibrium variable profits per customer in the oligopoly market. If fixed costs do not change with N, then S_N decreases with increases in variable profits.[21] The entry threshold also decreases with decreases in fixed cost. The ratio

$$\frac{s_{N+1}}{s_N} = \frac{F_{N+1}}{F_N}\frac{[P_N - AVC(q_N, W)]d_N(Z, M, P_N)}{[P_{N+1} - AVC(q_{N+1}, W)]d_{N+1}(Z, M, P_{N+1})} \qquad (5)$$

[21] AGV incorporate quantity data in their analysis, which allows them to relax this assumption and identify separately changes in the toughness of competition from changes in fixed costs. They are able to rule out the possibility that only changes in fixed costs generate observed patterns of entry threshold ratios. They find that most of the effects on competition occur with the entry of a second and a third hospital. We assume that the cost of entry will not change with the number of entrants because the provision of individual hospital services is studied instead of entry of a new hospital. Thus the entry cost to an existing hospital of adding a particular service is unlikely to increase or decrease much whenever entry occurs.

measures the rate at which variable profits fall with entry. If hospitals provide the service at the same costs and if entry does not change competitive conduct, then $s_{N+1} = s_N$. On the other hand, a ratio greater than one implies that competitive conduct toughens as the number of firms increases.

IV. Product and Geographic Market Definition

The *product* market for hospitals is typically taken to be "general acute care inpatient hospital service" (Gaynor and Vogt (2000)) and there is not much dispute about this dimension of market definition if hospitals are treated as single product firms. Since we treat hospitals as multiproduct firms and analyze each service separately, defining the product market for these services is straightforward. For example, Cardiac Catheterization and Gastroenterology are in no way substitutes for one another and so are clearly in separate product markets. Table 1 describes the 46 different hospital services that we analyze in this paper.

The ideal experiment to define the *geographic* market for a hospital service would be a totally isolated geographic area where patients only seek the hospital service in the area and no patients come in from outside the area.[22] While there is no empirical market definition that will guarantee isolated markets for each particular service, we focus on geographic areas (MSAs or Counties) that will incur the minimum amount of market overlap and leakage. Before specifying a geographic market definition, we separate hospital services into two groups based on the number of hospitals providing these services in the continental U.S. Table 2 contains this information. The first group, which

[22] A complete discussion of geographic market definition in hospital markets is contained in Gaynor and Vogt (2000).

includes specialties such as Open Heart Surgery, Sports Medicine, and Neuro-Surgery, contains thirty-one hospital services that are provided by less than half of U.S. hospitals. Fifteen services that are provided by more than half of the hospitals are in the second group. Examples of these commonly provided services are Emergency Rooms, Orthopedic Surgery, and General Intensive Care. On average, people travel longer distances to receive the services in the first group than the services in the second group.

Since fewer than half of all hospitals provide the first group of services, whether or not to offer these services in some sense constitutes more of a strategic decision for hospitals than services that are typically offered by most if not all hospitals. To analyze entry behavior for these services we define geographic markets as "isolated" MSAs combined with "isolated" large counties. To get isolated MSAs, we start by identifying all MSAs in the continental U.S. as potential markets. Next, we eliminate MSAs that are within 50 miles of another MSA.[23] These criteria identify 141 MSAs.[24] To control for patient flows across geographic markets we estimate the model by including the fringe population of the MSA and the distance to the nearest and more populous MSA as control variables to minimize patients "leaking".[25]

To expand the sample we also include large isolated counties. We identify all counties that meet the following criteria: (a) have a population of at least 50,000 (some MSAs have a population of less than 100,000 so picking counties that have more than 50,000 people is somewhat reasonable); and (b) are at least 50 miles from a MSA and 15

[23] The distance is measured from the center of one MSA to the center of another MSA, where "center" means the center of the most populated area in the MSA.
[24] We also drop the six largest MSAs because their population is over two million. These MSAs might be too large to be a single geographic market. Our results are similar if we include these large MSAs.
[25] See DSS and AGV for additional discussion of geographic market definition for hospitals.

miles from a county that has at least 50,000 people. There are 78 counties meeting these criteria, which gives us a total number of markets equal to 219. Figure 1 illustrates the locations of these markets. Our market selection criteria exclude many large MSAs from the sample (e.g. MSAs in Chicago and New York). Also there are more markets in the Midwest and East than in the West. Figure 2 gives a snap shot of the hospital markets in the Kentucky area and locations of all hospitals in the state. There are nine MSAs and counties in the state that are included in the sample, and the majority of the counties have at least one hospital.

For the second group of commonly provided services, those provided by a majority of all hospitals, we consider all counties that have at least one hospital and a population of less than one million as potential markets. People are less likely to travel outside the county to seek these services. We eliminate the largest counties, like Orange County, CA, because there are a large number of hospitals in these markets and some of them may not compete on providing services such as CT scans. Thus the market could be too broadly defined if these large counties are used.[26]

V. Econometric Model

Following the augmented BR model, we are able to analyze the determinants of the number of suppliers of a particular medical service in a hospital market. For each hospital service, i, in each market, j, we can write

$$N_{ij} = f \text{ (supply shifters, demand shifters)} \qquad (6)$$

[26] Choosing one million people as a cutoff point is arbitrary, we also tried 1.2 and 1.5 million and the results are very similar.

where N_{ij} is the number of hospitals that provide service i in market j. It takes on the values {0, 1, 2, … , M}. Therefore, the categorical variable N_{ij} is an ordered response and can be estimated using an ordered probit model if we assume the probability distribution of the error terms is normal.[27] The observed response for N_{ij} is conditional on the explanatory variables X (supply and demand shifters). Formally

$$N_{ij}^{*} = X\beta + e, \quad e|X \sim Normal(0,1)$$

where β is k x 1 and the intercept term is absorbed into the threshold parameters, which are described next. Let $\mu_1 \prec \mu_2 \prec \mu_M$ be unknown threshold parameters, and define

$N_{ij}=0$ if $N_{ij}^{*} \le \mu_1$

$N_{ij}=1$ if $\mu_1 \le N_{ij}^{*} \le \mu_2$

⋮

$N_{ij}=M$ if $N_{ij}^{*} \ge \mu_M$

Given the standard normal assumption for e, the conditional distribution of N_{ij} given X can be derived and the response probability for each category can be computed:

$$P(N_{ij} = 0 \mid X) = \Phi(\mu_1 - X\beta)$$

$$P(N_{ij} = 1 \mid X) = \Phi(\mu_2 - X\beta) - \Phi(\mu_1 - X\beta)$$

[27] One can also use an ordered logit model if the probability distribution of error terms is logistically distributed. Greene (2000) points out that there is not much difference between the two models in most applications (p. 737).

$$\vdots$$

$$P(N_{ij} = M - 1 \mid X) = \Phi(\mu_M - X\beta) - \Phi(\mu_{M-1} - X\beta)$$

$$P(N_{ij} = M \mid X) = 1 - \Phi(\mu_M - X\beta)$$

where Φ is the cumulative normal distribution. The parameters μ and β can be estimated by maximum likelihood, and then the value of $X\beta$ can be computed for a particular market. If $X\beta$ exceeds a particular threshold value μ, then we predict the market will have at least the number of providers associated with that threshold. Since the observed values of N are an ordinal ranking, the distance between the N's is not constant, meaning that the level of market demand for three hospitals is not necessarily three times the demand for one hospital. By estimating the thresholds, we can obtain information about competitive behavior and economies of scale.[28]

Table 3 lists the 31 services offered by fewer than half of hospitals and the number of isolated MSAs and counties that have none, one, two, three, and four or more hospitals providing the services. Because the ordered probit model requires several observations in each market size, we combine some markets into one group. For example, markets where more than four hospitals have cancer centers are grouped with markets where only four hospitals provide the service. These are services that are not offered by all hospitals, and so each hospital must decide strategically whether or not to enter this particular product market. Table 4 lists the 15 services offered by a majority of hospitals

[28] A critical assumption of the ordered probit model is that the slope coefficients β_k are not different between the outcomes $N_{ij} = 1, \ldots, M$. The validity of the assumption can be tested by estimating a multinomial logit model on the same data. The test results show that the assumption can not be rejected.

and the number of counties that have none, one, two, three, four, and five or more hospitals providing the services.

Substituting the supply and demand shifters into equation (6), we can write the final estimating equation as follows:

$$N_{i,j} = f(\beta_1 POPULATION_j + \beta_2 INCOME_j + \beta_3 WAGE_j + \beta_4 CON_j + \beta_5 HMO_j + \beta_6 WHITE_j + \beta_7 OLDER_j + \beta_8 RENT_j + \beta_9 NONPROFITi_j) \quad (7)$$

N_{ij} is the number of hospitals that provide service i in market j. The subscript i is dropped for all covariates since the value of the covariates in a market do not change across services (the equation is estimated for each individual service). POPULATION is the natural log of total population in market j in 2001. INCOME is per capita income measured in thousands of dollars in market j in 2000. WAGE is the hourly wage of nursing aides and orderlies.[29] CON (Certificate of Need programs) is a binary variable that equals one if a market is regulated by the programs. HMO is the percentage of population enrolled in Health Maintenance Organizations (HMOs) in 1998. WHITE is the percentage of 2001 population in a market whose racial category is white. OLDER is the percentage of the population 65 years or older. RENT is the gross median residential rent in a market in 2000.[30] NONPROFIT is the fraction of not-for-profit hospitals in a market.[31]

[29] The hourly wage for nursing aides and orderlies is only available at the MSA and state level. We assign the state average hourly wage for nursing aides and orderlies to the 78 isolated counties which are part of the sample.
[30] As do AGV, we include RENT as a measure of the cost of hospital facilities or buildings.
[31] Hospitals owned by local governments are categorized as not-for-profit hospitals.

VI. Data

Critical for our analysis are data on hospitals in the U.S., specifically, what types of special services each hospital provides. Such information is available from Billian's HealthDATA Group (BHDG), which collects a comprehensive nationwide hospital directory and health care data. Every year BHDG publishes the Hospital Blue Book (HBB), which contains hospital-specific data items on virtually every hospital in the U.S., including organizational structure, total beds, admissions, discharge, personnel, and hospital facilities and services. There are a total of 6579 hospitals contained in HBB (2001), and 5135 hospitals are left after excluding psychiatric hospitals, rehabilitation hospitals, children special hospitals, federal hospitals, hospitals in Puerto Rico, Alaska, Hawaii, and Virgin Islands, and skilled nursing facility care and others. The table below illustrates the number of hospitals that are in each category.

Total Number of Hospitals		6579
Missing zip (hospitals under construction)	-	53
Psychiatric Hospitals	-	316
Rehabilitation Hospitals	-	156
Children Special Hospitals	-	149
Federal Hospitals	-	248
Hospitals in Puerto Rico, Alaska, Hawaii, and Virgin Islands	-	105
Skilled Nursing Facility Care and Others	-	417
Total Number of Medical Surgery and Acute Care Hospitals (sampled hospital)	=	5135

HBB categorizes hospital services into eighty-two groups. The psychiatric and rehabilitation services are excluded because hospitals that *only* provide either one of these two services are excluded from the hospital sample mentioned above. Other services are excluded because there are few hospitals providing the service (e.g., Organ Transplant, Burn Care Unit, Trauma Center, etc.) or because these are services on which hospitals are

unlikely to compete (e.g., Blood Bank, Auxiliary, etc.), leaving us with the 46 services described in Table 1 for this analysis.

HMO enrollment data are obtained from the Area Resource File, which contains national county-level health resources data. Data on population and gross median rent are from the U.S. Bureau of Census. Gross rent is the contract rent plus the estimated average monthly cost of utilities (electricity, gas, water and sewer) and fuels if these are paid by the renter. Income per capita is from the Bureau of Economic Analysis, which prepares regional economic accounts for the U.S. The average hourly wage for nursing aides and orderlies in the year 2001 is from the Bureau of Labor Statistics.

Table 5 reports summary statistics of the variables when we analyze strategically provided services and the geographic market definition is isolated MSAs and counties. There are 219 isolated MSAs and counties in the sample (141 MSAs and 78 counties). As can be seen, the smallest market in terms of population size has 50,970 people and there are 1,965,440 people living in the largest market.[32] Income per capita ranges from $13,460 to $36,420. The wage for nursing aides and orderlies varies from $6.36 to $12.04 per hour. There are 69% of the markets regulated by a CON program to some degree (72% or 36 states have CON programs). The variation in HMO enrollment is significant—nobody was enrolled in any form of HMO in some markets in 1998 while approximately 74% of the population was enrolled in other markets. The proportion of people who are white varies from about 16% to 98%. On average, 13% of people in

[32] MSAs that have more than 2 million people are excluded from the sample because they may be too large to be considered a single geographical market for the 31 services. However, the results are similar if these MSAs are included.

sampled markets are older than 65. Median rent varies between $352 and $723. Lastly, 85% of hospitals beds on average are owned by not-for-profit hospitals.

Table 6 reports summary statistics of the variables when we analyze commonly provided services and the geographic market definition is all counties. There are 2073 counties identified after excluding counties that either do not have a hospital or have more than one million people.[33] The least populous county that has at least one hospital has 1,220 residents. Income per capita ranges from $10,530 to $68,760. The percent of the population 65 or older ranges from 3% to 36%.

VII. Empirical Results: Strategically Provided Services

We first report ordered probit results for each of thirty-one special services that are provided by less than half of U.S. hospitals. These are mainly provided locally by medium or large hospitals, which can strategically choose whether to offer a particular service based on the level of market competition and demand conditions. Geographical markets for these services are defined as isolated MSAs and Counties. Full regression results are reported in Appendix Table 1. The signs and magnitudes of coefficients for most services are consistent with expectations. The coefficients on total market population (POPULATION) are all positive and significant at 1% for every service. Market size, as measured by population, has a significant effect on entry decisions of hospitals. The z values for most services are quite large (around 10), which supports the hypothesis that the equilibrium number of special hospital services in a market is mainly

[33] The largest counties are excluded because some hospitals in a large county might not compete with each other for patients seeking hospital services such as ER or Labor/Delivery. The results are similar if all counties are included.

determined by the population size. The regression results validate the application of the population threshold method in the hospital industry when analyzing firms' competitive behavior.

The coefficients on income per capita (INCOME) are positive and significant for most services.[34] The level of significance of the income coefficients generally reflects the differential effect of income on the provision of different services. For example, income is estimated to be a more important factor in hospitals' decisions to provide Radiation Therapy services than to add a Pain Center. Interestingly, out of the eight special services where income is not significant at conventional levels, four involve mainly elderly patients: Nursing Home, Skilled Nursing, Hospice, and Geriatric. The provision of Obstetrical care is also not significantly affected by the level of income, which is not surprising in that obstetrical care for every pregnant woman is roughly the same regardless of financial situation. So it is plausible that income is not a factor in determining the provision of obstetrical care by hospitals.[35] In general, however, the higher is per capita income in a market the higher is the rate of provision of hospital services.

The costs of labor for hospitals, as measured by hourly wages of nursing aides and orderlies (HOURLY WAGE), affect the provision of many special services. For many other services, however, the importance of labor costs in hospitals' entry decisions

[34] Significant at 10% for 5 services: Aids/ARC, Wellness Center, Pain Center, Lithotripsy, and Ophthalmologic Services; at 5% for 7 services: Linear Accelerator, Cancer Center, Neuro-Surgical Services, Women's Center, Neurological Services, Reconstructive/Plastic Surgery, and Sports Medicine; and at 1% for 11 services: Open Heart Surgery, Case Management, Intensive Neonatal Care, Sleep Disorder, Radiation Therapy, Histopathology, Cardiac Catheterization Lab, Dialysis, Laser Surgery (Ophthalmology), Pediatric Services, and Cardiology.

[35] The other three services that are not significantly affected by income are Occupational Medicine, Aeromedical Heliport, and Alcohol Inpatient.

is not significant. The coefficients are negative and significant for 11 out of 31 services.[36] The coefficients for Certificate of Need regulations are *positive* and significant for nine of the 31 services.[37] This result indicates that the supply of these services is higher in states that regulate hospital entry and the addition of new services than in states without such regulations. Simpson (1995) offers a possible explanation for this unexpected result. He finds that that the CON programs are probably effective in rural areas but not in urban areas. Since most large hospitals are located in urban areas (likely MSAs), their entry and exit decisions are less likely to be affected by CON programs due to significant entry and exit costs. If CON programs are effective in regulating the entry of small hospitals, the result may be that incumbent hospitals add capacity, resulting in more large hospitals in a market. Consequently, the number of hospitals offering services in this selected group will increase due to the regulations because they are mainly offered by large hospitals. Skilled Nursing is the only service that has a negative coefficient on CON, statistically significant at 5 %. The coefficient is also negative but not significant for Nursing Home. Both Skilled Nursing and Nursing Home provide long-term care to patients and are highly regulated by all CON states, thus it is expected that CON would impact these two services more than other services.

Enrollment in health maintenance organizations (HMOs) generally has no effect on the provision of this group of services. The coefficients are negative and statistically

[36] Significant at 10% for 5 services: Wellness Center, Women's Center, Neurological Services, Sleep Disorder, and Radiation Therapy; at 5% for 2 services: Linear Accelerator and Intensive Neonatal Care; and at 1% for 4 services: Cancer Center, Open Heart Surgery, Reconstructive/Plastic Surgery, and Cardiac Catheterization Lab.

[37] Significant at 10% for 1 service: Obstetrical Services; at 5% for 5 services: Linear Accelerator, Neuro-Surgical Services, Reconstructive/Plastic Surgery, Laser Surgery (ophthalmology), and Ophthalmologic services; and at 1% for 3 services: Neurological Services, Sleep Disorder, and Lithotripsy. Some of the services are regulated by CON (e.g. Neurological services and Lithotripsy), while others are not (e.g. Reconstructive/Plastic Surgery and Sleep Disorder).

significant for only three services, Neuro-Surgical Services (at 10%), Lithotripsy (at 5%), and Sleep Disorder (at 1%). Race is a significant factor in only two services, Cancer Center and Dialysis. Cancer incidence rates do not differ appreciably by race, so this cannot explain this result. The result for Hemodialysis, however, may reflect differential incidence rates—the medical literature indicates that blacks are 30% more likely to have diabetes than whites (Rogers, 1992; Honeycutt, et al,, 2003), and diabetes is the leading cause of chronic kidney disease (over 40% of patients who need dialysis had diabetes).

As expected, the proportion of older population has a positive correlation with the number of hospitals providing a particular service for most categories.[38] The only negative and significant coefficient on OLDER is for Intensive Neonatal services. There is some evidence that a higher proportion elderly corresponds to a lower number of Alcohol Inpatient service providers. The only unexpected result regarding the age variable is that Geriatric Services is not correlated with the proportion older population. The cost of facilities or buildings, measured by the median rent (RENT) in a market, plays an important role in hospitals' decisions to add a new service. The coefficient on RENT is negative and significant for every service.[39]

The last covariate is ownership of hospitals, measured by the proportion of not-for-profit hospital beds in a market. The regression results show that the market share of not-for-profit hospitals has no significant effect on the provision of most services. There is no significant evidence to support the argument that not-for-profit hospitals behave

[38] Significant at 10% for Laser Surgery, 5% for 6 services: Occupational Medicine, Nursing Home, Women's Center, Hemodialysis, Ophthalmologic Services, and Cardiology, and at 1% for 4 services: Wellness Center, Reconstructive/Plastic Surgery, Histopathology, and Skilled Nursing.
[39] Significant at 10% for 2 services: Intensive Neonatal Care and Aids/ARC; at 5% for 2 services: Obstetrical Services and Wellness Center; and at 1% for the rest of the 27 services.

differently from for-profit hospitals in terms of how they respond to market competition, at least for the group of services examined here. Only four services have a negative (significant at the 5% level) coefficient on the ownership variable, Case Management, Obstetrical Services, Sports Medicine, and Cardiac Catheterization. In the provision of only two services, Linear Accelerator and Hospice, is not-for-profit ownership share positively (significant at the 5% level) related. The results thus are mixed—the number of providers for some services will increase with the market share of not-for-profit hospitals while the number of providers for other services will decrease or be unaffected.

Table 7 calculates the size of the total population needed to support a given number of providers in each of the specific services. When calculating the threshold population, we exclude services (1) that do not have enough observations in each group[40] (Occupational Therapy, Linear Accelerator, Nursing Home, Case Management, Aero Medical Heliport, and Aids/ARC); (2) where hospitals are unlikely to compete (Wellness Center, Pain Center, Hospice, and Geriatrics); and (3) that are provided by not only hospitals but also non-hospital facilities (e.g. stand-alone Skilled Nursing Facilities).[41] The calculations are based on the coefficient estimates in Appendix Table 1. Given the estimated threshold values, μ_1, μ_2, μ_3, and μ_4, for each service, we calculate the level of population necessary for $X\beta$ to cross each threshold level. All the values are evaluated at their mean with the exception of the binary variable CON, which we set equal to one.

[40] There is no standard requirement regarding the number of observations needed in each category when estimating ordered probit models, however, at least 5% of the sample in each category is generally used in empirical work.

[41] The regression results discussed earlier, i.e. the signs and statistical significance of the coefficients, are mainly valid for these services even though there are fewer than 10 observations in some groups. Calculation of the threshold population could be problematic, however, because the ordered probit standard errors of the threshold values used to calculate the threshold population are large.

For example, when calculating the total population needed to support one hospital to provide a particular service, we hold constant the mean value of all variables (except for population) for all markets that do not provide the service, and then keep increasing the population until $X\beta$ equals μ_1. When calculating the total population needed to support two hospitals, we hold constant the mean value of all variables for all markets that already have one provider of the service, and then increase the population until $X\beta$ equals μ_2. As an example, the total population needed for one hospital to provide open heart surgery is about 122,000, while 227,500 people are needed for two hospitals to provide the service. The population must be around 72,200 for a market to have one cancer center, while 262,400 people are needed for two.

Table 8 presents the ratios, $(S_{n+1}/n+1)/(S_n/n)$, of successive per firm entry thresholds. A large threshold ratio, $(S_2/2)/S_1$, indicates that strategic entry deterrence by an incumbent monopoly provider might be present in the market for a particular service. An incumbent might strategically deter entry through irreversible investments; for example, an existing hospital might purchase specialized equipment or expand capacity to provide the specific medical service. The larger the ratio, the greater is the change in the level of competitiveness as the number of suppliers increases. The ratio will approach unity as the number of service providers increases if the market is converging to a competitive equilibrium. There are eight services that tend to approach a competitive equilibrium after the third or fourth hospital enters the market. Four of these, Intensive Neonatal, Women's Center, Lithotripsy, and Sports Medicine, are services categorized by Horwitz and Nichols (2007) as being profitable for a hospital to offer, while three others, Neuro-

Surgical, Neurological, and Histopathology, are not classified. Only Alcohol Inpatient among the eight is classified as unprofitable by Horwitz and Nichols.

Threshold ratios for the other eleven services do not show this pattern. In three service markets, Reconstructive/Plastic surgery, Laser Ophthalmology, and Ophthalmologic Services, entrants do not appear to have much effect on incumbents' competitive behavior. These services usually are not covered by insurance and are by nature non-acute, therefore patients will have more options. In addition, free-standing clinics also provide these services and these clinics are not included in the sample. For Cancer Centers, Radiation Therapy, Obstetrical, Pediatric Services, and Dialysis there is no convergent pattern, which indicates that the effects of successive entrants on competition do not fade away. The competitive structures for Open Heart Surgery, Cardiac Catheterization, and Cardiology warrant special mention. Our results indicate that the size of the population needed to support one hospital does not change significantly when the market changes from monopoly to duopoly (see the threshold ratio, $(S_2/2)/S_1$). Duopolists, however, seem to be able to deter entry when a third or fourth hospital attempts to enter the market, as indicated by the threshold ratio, $(S_3/3)/(S_2/2)$. There is an incentive for hospitals to collude implicitly in the market for these services, because these services are very profitable.[42] The estimated threshold ratios also illustrate that hospitals experience economies of scale in providing most of this set of services. For example, the population needed to support each Cancer Center increases from about

[42] In his analysis of hospital acquisitions in New York, Huckman (2006) calculates that hospitals earned average profits of $2000 for each coronary artery bypass graft procedure and $2100 for each angioplasty procedure.

72,000 to 300,000 when we go from a monopoly market to an oligopoly market with four firms.

VIII. Empirical Results: Commonly Provided Services

In the previous section services provided by less than half of U.S. hospitals were analyzed using isolated MSAs and counties as the geographic market definition. If hospitals behave strategically in their decisions about which specific medical services to offer, it will most likely show up in these settings. Now we turn to the second group of 15 services that are provided by the majority of hospitals. Strategic entry deterrence is less likely to show up in these services. Patients are less likely to travel long distances to obtain these services, and so we choose to define the geographic market as counties, a smaller geographical market than most MSAs. There are 2073 counties identified after excluding counties that either do not have a hospital or have more than 1 million people.[43]

Our empirical approach is as before, with two exceptions. Since data on hourly wages of nursing aides and orderlies are only available at the state level, we use the hourly wage for medical record[44] in this section. We also include a new variable, COMMUTE, which is the percentage of workers in a county who commute 45 minutes to work. It is included to control for patient outflows, i.e., people who travel a long distance to work and who may seek health care in hospitals close to their work place.

[43] Large population counties are excluded because all hospitals in a large county might not compete with each other for patients seeking hospital services such as ER or Labor/Delivery. Our results are similar if all counties are included.

[44] The hourly wage for medical record is available at state and MSA levels, but not the county level. Counties within a MSA are assigned the MSA level hourly wage, and the state level wage is assigned otherwise.

Appendix Table 2 presents coefficient estimates for each of the 15 services. The coefficients on POPULATION are still all positive and significant at 1% for each individual service. Among the more interesting results are that the coefficients on INCOME are positive and significant at 5% or 1% for all services except three, Ultrasound, ER, and Respiratory. In contrast to the earlier results for strategically provided services in isolated MSAs and counties, the coefficients on CON are negative and significant at 5% or 1% for all services except two, Oncology and Gastroenterology. This result indicates that CON programs affect the entry of hospital services in rural areas, because a large number of counties in this sample are in rural areas.[45] The negative coefficients could also reflect the effect of CON programs in limiting the entry of new hospitals themselves in rural areas, since these 15 services are provided by a majority of hospitals. For several medical services there is some evidence that not-for-profit hospitals are less likely to enter than for-profit hospitals. The coefficients on NOT-FOR-PROFIT are negative and significant at 5% for five services (Gastroenterology, MRI, Intensive General Care, CTscan, and ER). Patient outflows (COMMUTE) are negatively correlated with the provision of most services, which reflects that the geographic markets are narrowly defined. Generally the regression results show the provision of these 15 services by hospitals in a county mainly depends on population size, income per capita, CON, cost of capital, proportion of elderly, and number of commuters.

Table 9 presents the size of the population needed to support a given number of providers of each of the fifteen hospital services for counties regulated by CON programs. The total population needed for one hospital to provide Oncology is about 51,000, and

[45] The findings are consistent with those by Santerre and Pepper (2000).

321,600 people are needed for two hospitals to provide the service. Ultrasound will be provided when a county's population reaches 3,600 and ER will be provided in a county that has as few as 1,900 people. The ratios $(S_{n+1}/n+1)/(S_n/n)$ are listed in Table 10. The results show that threshold ratios decrease monotonically toward unity as more hospitals enter the markets for these services. The ratio $(S_2/2)/S_1$ is fairly large for most of the services, especially when compared to the results for strategically provided services in Table 8, but declines fairly sharply in almost all cases as the number of entrants increases. This can be interpreted as implying that competition increases dramatically with the entry of a second hospital provider for these services, or that essential services like emergency rooms will be included in a hospital's product mix no matter how small the market. After the third or fourth entrant the ratio for most of these services is approaching one. The large initial threshold ratios may result from CON regulations or possibly from strategic entry deterrence. More importantly, the pattern of threshold ratios seems to indicate that strategic behavior may occur at the hospital level and not at the specific service level for these services that are offered by a majority of hospitals. This result accords with Abraham, Gaynor, and Vogt's (2007) findings for entry into small to medium-sized hospital markets.

IX. Summary and Conclusions

Most general service hospitals offer a common bundle of services such as emergency rooms, labor/delivery, general surgery, intensive care, and general diagnostics like CT scans and MRIs. A wide range of other medical services, however, are offered more selectively. For example, among the over five thousand hospitals in our

comprehensive nationwide sample, only eighteen percent offered open heart surgery, thirty percent performed lithotripsy, thirty-one percent had sports medicine clinics, and thirty-eight percent had dialysis capability. It would thus seem that for commonly provided services such as emergency rooms competition occurs at the firm level, because entrants typically bundle emergency rooms with services such as labor/delivery, ambulatory surgery, general intensive care, and intensive cardiac care. Offering sports medicine or a women's center, however, is more elective, since a majority of hospitals do not offer these services. A hospital's decision to offer a sports medicine clinic is separate from the decision to enter the market for general hospital services, and so competition occurs at the product level.

We have used the approach developed by Bresnahan and Reiss (1991) to analyze entry and competition in markets for specific hospital services. We distinguish between commonly provided services, supplied by a majority of hospitals, and strategically provided services, supplied by fewer than half of hospitals. For commonly provided services, competition increases dramatically with the entry of a second hospital provider, and a competitive equilibrium is generally reached after the third or fourth entrant. This result matches up with Abraham, Gaynor, and Vogt's (2007) findings for firm-level entry into small to medium-sized hospital markets. For strategically provided services, we find that there are eight services that tend to approach a competitive equilibrium after the third or fourth hospital enters the market. We find that threshold ratios for eleven other services do not show this pattern, and for three cardiology related services, some strategic behavior may be present in duopoly markets.

We thus find evidence that general service hospitals behave strategically in the supply of certain medical services. Whether alternative organizational forms are allowed to compete with general service hospitals is a current topic of dispute. Single-specialty hospitals and ambulatory surgery centers have entered a number of hospital markets and are competing alongside general hospitals. Many of these specialty centers are for-profit firms, and as such are attracted to enter geographic markets for specific medical services that are profitable to supply. To the extent that general service hospitals currently choose to supply certain services that are profitable and use the profits to cross subsidize unprofitable services, they may be vulnerable to entry by specialty clinics and hospitals.

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TABLE 1 --DESCRIPTIONS OF SERVICES

Aero medical Heliport	Provides helicopter/air transport with heliport landing surface
Aids/ARC	Diagnosis and treatment of Aids and Aids related complex
Alcohol Inpatient	Beds set up and staffed in unit(s) providing diagnostic and therapeutic services
Ambulatory surgery	Surgical service on outpatient basis with lab and other diagnostic testing as ordered by physician
Birth Room	Combination labor/delivery unit with home-like setting
Cancer Center	Offers full range of diagnostic and treatment services approved by American College of Surgeons
Cardiac catheterization Lab	Diagnostic procedure includes introducing catheter into interior of heart through vein or artery or by direct needle puncture
Cardiology	Cardiac studies, tests and evaluations not conducted in catheterization lab or operating room
Case Management	A model of patient care delivery that utilizes a case manager to coordinate interdisciplinary treatment
CTscan	Computerized Tomography Scanner-for head or whole body scans
ER	In-hospital facilities providing unscheduled outpatient services, must be staffed 24 hours/day
Gastroenterology	Diagnosis and treatment of stomach and intestines
Geriatric Services	Medical or surgical services for older adults
Hemodialysis	Inpatient or outpatient dialysis treatment of renal (kidney) insufficiencies
Histopathology	Tissue specimens examined by qualified pathologist
Home Health	Nursing, therapy, and home-related or social services in patient's home
Hospice	Medical relief of pain and supportive services for terminally ill patients and their families in inpatient and home care
Intensive Cardiac	Unit staffed with specially trained personal, containing monitoring and support equipment for patients with seizures, open heart surgery, or other life threatening conditions
Intensive General	Patient care requiring intensified, comprehensive observation and care due to shock, trauma, or other life threatening conditions
Intensive Neonatal	Unit must be separate from newborn nursery, providing intensive care to all sick infants.
Labor/Delivery	Services for maternity and newborn cases; supervised by maternal/fetal specialist(s).
Laser Surgery (Ophthalmology)	Surgical procedure that uses laser to precisely reshape the cornea.
Linear Accelerator	Apparatus for accelerating charged subatomic particles used to deliver super voltage X-ray to patients receiving radiotherapy
Lithotripsy	Device used for treating kidney or ureter stones
MRI	Uniform magnetic field and radio frequencies to study tissue and structure of body
Neurological	Diagnostic services dealing with disorders of the nervous system
Neuro-Surgical	Surgery of the nervous system
Nuclear Medicine	Radioisotopes as tracers or indicators to detect abnormal condition/disease

Nursing Home	Provides nursing or personal care services to the older population or chronically ill
Obstetrical	Services provided for the management of women during pregnancy, childbirth and puerperium
Occupational Medicine	Consultation in the areas of preventive medicine, travel medicine, occupational health,
Oncology	Therapeutic treatment of tumors including radium, cobalt, radioisotopes, etc.
Open Heart	Proper equipment and staff to perform surgery where chest is opened and blood is recirculated and oxygenated
Ophthalmologic	Diagnosis and treatment of eye diseases
Orthopedic Surgery	Procedures devoted to treatment of skeletal system
Pain Center	Scales, tests, and other methods to assess pain severity and duration to aid diagnosis and therapy
Pediatric Services	Acute care to pediatric patients
Radiation Therapy	Medical use of ionizing radiation as part of cancer treatment to control malignant cells
Reconstructive/Plastic	The use the surgery to reconstruct damaged or malformed tissues or organs
Respiratory	Oxygen and specific drugs through inhalation or positive pressure
Skilled Nursing	Provided for patients not in acute phase of illness but requiring convalescence with physician services and professional nursing supervision
Sleep Disorder	Study and treatment of disruptions of sleep
Sports Medicine	Diagnostic screening and assessment, for sport-related injuries
Ultrasound	Visualizing internal body structure by use of acoustic waves
Wellness Center	Exercise, testing, or evaluation with fitness activities
Women’s Center	Designated area for physical, psychosocial, physiological diagnosis, and treatment for women

TABLE 2 --MEDICAL SERVICES AND THE NUMBER OF HOSPITALS PROVIDING EACH SERVICE *

Service	N. of Hospitals	Fraction	Service	N. of Hospitals	Fraction
Occupational Medicine	799	0.156	Cardiac Catheterization Lab	1838	0.358
Linear Accelerator	871	0.170	Skilled Nursing	1865	0.363
Cancer Center	881	0.172	Dialysis	1926	0.375
Open Heart	937	0.182	Laser Surgery	2095	0.408
Nursing Home	929	0.181	Ophthalmologic	2340	0.456
Case Management	937	0.182	Geriatric Services	2406	0.469
Neuro-Surgical	975	0.190	Pediatric Services	2550	0.497
Aero Medical Heliport	986	0.192	Cardiology	2599	0.506
Intensive Neonatal	1069	0.208	Oncology	2848	0.555
Alcohol Inpatient	944	0.184	Gastroenterology	2881	0.561
Aids/ARC	1155	0.225	Ultrasound	2935	0.572
Obstetrical	1191	0.232	Intensive Cardiac	2951	0.575
Wellness Center	1284	0.250	Home Health	2974	0.579
Pain Center	1378	0.268	MRI	3075	0.599
Women’s Center	1416	0.276	Birth Room	3147	0.613
Neurological	1426	0.278	Orthopedic Surgery	3304	0.643
Sleep Disorder	1476	0.287	Labor/Delivery	3478	0.677
Lithotripsy	1518	0.296	Nuclear Medicine	3702	0.721
Radiation Therapy	1536	0.299	Intensive General	3909	0.761
Reconstructive/Plastic	1573	0.306	Ambulatory surgery	4189	0.816
Sports Medicine	1590	0.310	CTscan	4366	0.850
Hospice	1816	0.354	ER	4610	0.898
Histopathology	1826	0.356	Respiratory	4621	0.900

*Total of 5135 hospitals in continental U.S. excluding Psychiatric, Rehabilitation, Federal, Children's Specialty hospitals, and others.

TABLE 3—MARKET STRUCTURE FOR SELECTED HOSPITAL SERVICES* (ISOLATED MSAS AND COUNTIES)

Group	N=0	N=1	N=2	N=3	N>=4
Occupational Medicine	104	74	24	10	7
Linear accelerator	69	98	27	16	9
Cancer Center	59	97	35	17	11
Open Heart	84	61	36	15	23
Nursing Home	118	69	21	7	4
Case Management	104	70	27	10	8
Neuro-Surgical	76	81	34	11	17
Aero medical Heliport	94	74	31	6	14
Intensive Neonatal	70	80	36	17	16
Alcohol Inpatient	87	86	22	10	14
Aids/ARC	101	69	25	7	17
Obstetrical	89	82	23	14	11
Wellness Center	67	84	28	19	21
Pain Center	71	67	39	18	24
Women's Center	60	73	43	12	31
Neurological	58	84	41	11	25
Sleep Disorder	47	97	38	13	24
Lithotripsy	27	96	50	13	33
Radiation Therapy	35	95	47	16	26
Reconstructive/Plastic	59	70	41	18	31
Sports Medicine	53	83	49	9	25
Hospice	62	85	34	17	21
Histopathology	46	85	41	17	30
Cardiac catheterization Lab	30	80	50	20	39
Skilled Nursing	58	68	41	21	31
Dialysis	35	89	39	21	35
Laser Surgery	31	80	48	24	36
Ophthalmologic	29	88	43	21	38
Geriatric Services	49	71	38	22	39
Pediatric Services	17	78	53	30	41
Cardiology	18	76	53	29	43

*31 services provided by less than 50% of hospitals from Table 2.

TABLE 4—MARKET STRUCTURE FOR SELECTED HOSPITAL SERVICES*
(ALL COUNTIES)

Group	N=0	N=1	N=2	N=3	N=4	N>=5
Oncology	872	799	213	95	33	61
Gastroenterology	861	804	224	88	33	63
Ultrasound	536	1139	257	69	36	36
Intensive Cardiac	790	864	244	80	36	59
Home Health	599	1054	262	82	41	35
MRI	685	960	240	88	40	60
Birth Room	544	1077	272	89	37	54
Orthopedic Surgery	661	944	248	101	40	79
Labor/Delivery	428	1127	323	88	47	60
Nuclear Medicine	474	1079	288	107	45	80
Intensive General	439	1080	307	104	53	90
Ambulatory surgery	254	1212	347	121	43	96
CTscan	171	1276	357	122	53	94
ER	34	1350	402	138	53	96
Respiratory	114	1297	364	140	53	105

*15 services provided by more than 50% of hospitals from Table 2.

TABLE 5—SUMMARY STATISTICS (ISOLATED MSAS AND COUNTIES)

Variable	Obs.	Mean	Std. Dev.	Min	Max
Population[a]	219	156.15	2.50	50.97	1965.44
Income[b]	219	24.61	3.53	13.46	36.42
Wage[c]	219	8.88	1.12	6.36	12.04
Certificate of Need[d]	219	0.69	0.46	0.00	1.00
HMO enrollment[e]	219	14.90	14.40	0.00	74.18
White[f]	219	81.87	13.40	16.39	98.35
Older (>=65)	219	12.96	3.18	6.57	33.00
Rent[g]	219	492.47	70.43	352.00	723.00
Nonprofit[h]	219	0.85	0.22	0.00	100.00

Note: MSAs that have more than two million people are excluded.
[a] Population in 1000s;
[b] Per capita income in $1000s;
[c] Hourly wage in dollars of nursing aides and orderlies;
[d] Equals to one if MSAs are regulated by Certificate of Need program, zero otherwise;
[e] Percentage of population enrolled in HMOs;
[f] Percentage of population that is white;
[g] Median gross rent in dollars;
[h] Fraction of total beds owned by not-for-profit hospitals;
Sources: Hospital Blue Book (Nonprofit); Area Resource File, 2003 (HMO enrollment); U.S. Bureau of Census (Population, White, Older, and Rent); Bureau of Economic Analysis (Income); American Health Planning Association (Certificate of Need).

TABLE 6—SUMMARY STATISTICS (ALL COUNTIES)

Variable	Obs.	Mean	Std. Dev.	Min	Max
Population[a]	2073	38.76	3.50	1.22	985.16
Income[b]	2073	23.21	5.44	10.53	68.76
Wage[c]	2073	15.01	2.07	10.67	26.33
Certificate of Need[d]	2073	0.68	0.47	0.00	1.00
HMO enrollment[e]	2073	11.92	13.43	0.00	96.94
White[f]	2073	84.32	16.10	13.06	99.47
Older (>=65)	2073	14.55	3.88	3.16	35.59
Rent[g]	2073	453.76	102.64	323.71	1039.00
Nonprofit[h]	2073	0.86	0.31	0.00	100.00
Commute[i]	2073	15.37	7.60	1.31	48.17

Note: Counties that have more one million people are excluded.
[a] Population in 1000s;
[b] Per capita income in $1000s;
[c] Hourly wage in dollars for medical records;
[d] Equals to one for counties regulated by Certificate of Need program, zero otherwise;
[e] Percentage of population enrolled in HMOs;
[f] Percentage of population that is white;
[g] Median gross rent in dollars;
[h] Fraction of total beds owned by not-for-profit hospitals;
[i] Percentage of people who commute over 45 minutes to work;
Sources: Hospital Blue Book (Nonprofit); Center for Medicare and Medicaid Services (Wage); Area Resource File, 2003 (HMO enrollment); U.S. Bureau of Census (Population, White, Older, Rent, and Commute); Bureau of Economic Analysis (Income); American Health Planning Association (Certificate of Need).

TABLE 7—TOTAL POPULATION (000) NEEDED TO SUPPORT THE NUMBER OF SERVICES FOR MARKETS REGULATED BY CON (ISOLATED MSAS AND COUNTIES)

	S_1	S_2	S_3	S_4
Cancer Center	72.2	262.4	486.5	1200.3
Open Heart	122.0	227.5	456.3	754.1
Neuro-Surgical	92.0	270.3	624.8	979.9
Intensive Neonatal	92.8	267.7	586.1	949.5
Alcohol Inpatient	97.9	356.4	763.6	1224.7
Obstetrical	103.8	557.1	1290.6	3070.2
Women's Center	76.9	196.1	401.3	556.4
Neurological	75.2	202.4	450.1	542.1
Lithotripsy	48.9	139.6	299.2	444.9
Radiation Therapy	59.0	166.3	348.4	632.6
Reconstructive/Plastic	75.0	170.7	281.3	446.4
Sports Medicine	70.3	224.7	563.0	874.3
Histopathology	60.6	170.9	322.6	486.8
Cardiac catheterization Lab	73.5	147.6	276.9	417.0
Dialysis	65.2	172.9	265.9	466.8
Laser Surgery	57.6	134.8	233.3	430.9
Ophthalmologic	52.2	132.5	250.9	407.7
Pediatric Services	43.7	116.5	214.1	413.8
Cardiology	52.7	112.6	207.6	364.0

TABLE 8—THRESHOLD RATIOS (ISOLATED MSAS AND COUNTIES)

	$(S_2/2)/S_1$	$(S_3/3)/(S_2/2)$	$(S_4/4)/(S_3/3)$
Cancer Center	1.82	1.24	1.85
Open Heart	0.93	1.34	1.24
Neuro-Surgical	1.47	1.54	1.18
Intensive Neonatal	1.44	1.46	1.22
Alcohol Inpatient	1.82	1.43	1.20
Obstetrical	2.68	1.54	1.78
Women's Center	1.27	1.36	1.04
Neurological	1.35	1.48	0.90
Lithotripsy	1.43	1.43	1.12
Radiation Therapy	1.41	1.40	1.36
Reconstructive/Plastic	1.14	1.10	1.19
Sports Medicine	1.60	1.67	1.16
Histopathology	1.41	1.26	1.13
Cardiac catheterization Lab	1.00	1.25	1.13
Dialysis	1.33	1.03	1.32
Laser Surgery	1.17	1.15	1.39
Ophthalmologic	1.27	1.26	1.22
Pediatric Services	1.33	1.22	1.45
Cardiology	1.07	1.23	1.31

TABLE 9—TOTAL POPULATION (IN 000) NEEDED TO SUPPORT THE NUMBER OF SERVICES FOR MARKETS REGULATED BY CON (ALL COUNTIES)

	S_1	S_2	S_3	S_4	S_5
Oncology	51.0	321.6	841.4	1777.5	2835.5
Gastroenterology	27.1	161.7	410.0	779.6	1125.9
Ultrasound	3.6	21.7	52.3	86.3	137.1
Intensive Cardiac	16.4	91.1	227.4	393.6	553.2
Home Health	4.2	21.9	52.8	95.9	163.2
MRI	25.7	199.2	519.5	994.9	1729.0
Birth Room	9.9	59.7	139.0	245.2	385.5
Orthopedic Surgery	26.8	209.0	506.9	1058.2	1549.3
Labor/Delivery	10.9	79.3	216.3	389.8	665.5
Nuclear Medicine	30.9	363.0	1102.3	2435.1	3762.2
Intensive General	24.5	301.3	896.6	1831.5	2965.9
Ambulatory surgery	6.2	68.2	182.2	368.3	485.1
CTscan	7.6	164.7	496.2	1122.3	1781.9
ER	1.9	59.7	165.4	344.1	526.9
Respiratory	4.1	100.7	283.4	625.5	1011.1

TABLE 10—THRESHOLD RATIOS (ALL COUNTIES)

	$(S_2/2)/S_1$	$(S_3/3)/(S_2/2)$	$(S_4/4)/(S_3/3)$	$(S_5/5)/(S_4/4)$
Oncology	3.15	1.74	1.58	1.28
Gastroenterology	2.98	1.69	1.43	1.16
Ultrasound	3.03	1.60	1.24	1.27
Intensive Cardiac	2.77	1.66	1.30	1.12
Home Health	2.62	1.61	1.36	1.36
MRI	3.87	1.74	1.44	1.39
Birth Room	3.02	1.55	1.32	1.26
Orthopedic Surgery	3.89	1.62	1.57	1.17
Labor/Delivery	3.65	1.82	1.35	1.37
Nuclear Medicine	5.87	2.02	1.66	1.24
Intensive General	6.15	1.98	1.53	1.30
Ambulatory surgery	5.47	1.78	1.52	1.05
CTscan	10.90	2.01	1.70	1.27
ER	15.51	1.85	1.56	1.23
Respiratory	12.23	1.88	1.66	1.29

FIGURE 1: HOSPITAL MARKETS (ISOLATED MSAS AND COUNTIES)

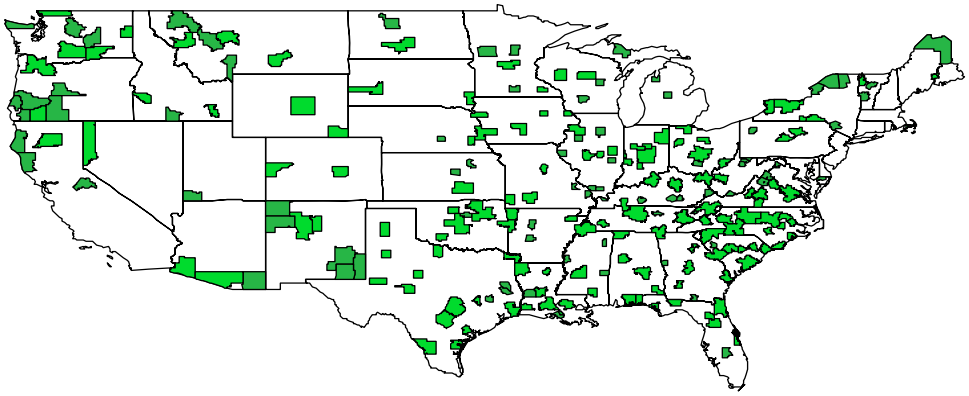
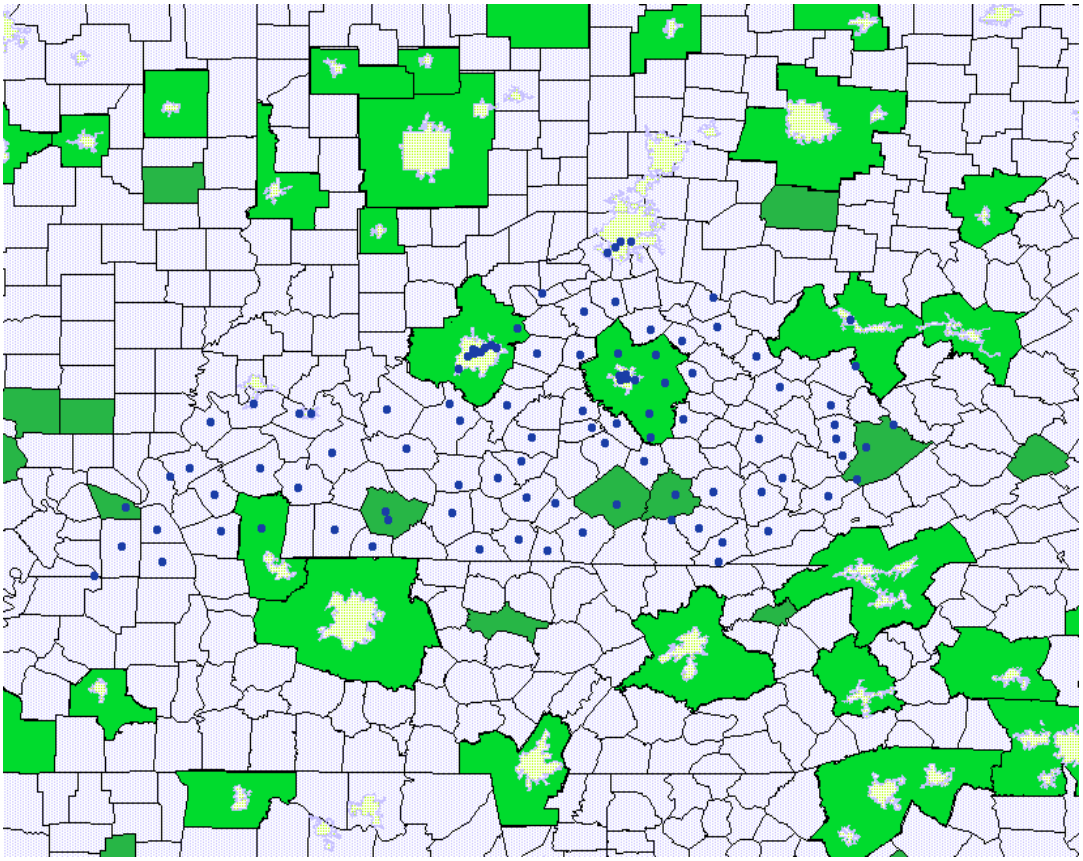


FIGURE 2: HOSPITAL MARKETS IN KENTUCKY AREA AND HOSPITAL LOCATIONS



APPENDIX TABLE 1: MAXIMUM LIKELIHOOD ESTIMATES USING ISOLATED MSAS AND COUNTIES

	Occupa-tional Medicine	Linear Accelerator	Cancer Center	Open Heart	Nursing Home	Case Manag-ement
Population	0.980	1.062	1.335	1.702	0.818	0.880
	(0.122)***	(0.124)***	(0.149)***	(0.149)***	(0.122)***	(0.124)***
Income	0.046	0.072	0.066	0.151	-0.022	0.079
	(0.031)	(0.034)**	(0.032)**	(0.031)***	(0.027)	(0.029)***
Wage	0.014	-0.177	-0.248	-0.348	0.392	-0.124
	(0.093)	(0.087)**	(0.090)***	(0.090)***	(0.094)***	(0.096)
CON	0.266	0.431	0.096	-0.152	-0.224	0.214
	(0.185)	(0.178)**	(0.174)	(0.185)	(0.171)	(0.188)
HMO	0.001	-0.002	-0.004	0.003	0.004	-0.003
	(0.008)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
White	-0.009	0.004	0.012	-0.001	0.000	-0.003
	(0.007)	(0.007)	(0.007)*	(0.008)	(0.008)	(0.007)
Older	0.055	-0.008	0.033	-0.024	0.071	0.001
	(0.027)**	(0.028)	(0.029)	(0.032)	(0.034)**	(0.028)
Rent	-0.006	-0.006	-0.006	-0.004	-0.005	-0.006
	(0.002)***	(0.001)***	(0.002)***	(0.002)***	(0.002)***	(0.002)***
Nonprofit	0.015	0.917	0.673	-0.213	-0.375	-0.720
	(0.355)	(0.389)**	(0.395)*	(0.404)	(0.400)	(0.365)**
Obs.	219	219	219	219	219	219

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX TABLE 1 (CONTINUED): MAXIMUM LIKELIHOOD ESTIMATES USING ISOLATED MSAS AND COUNTIES

	Neuro-Surgical	Aero medical Heliport	Intensive Neonatal	Alcohol Inpatient	Aids/ARC	Obstetrical
Population	1.226	1.080	1.276	1.133	1.059	0.731
	(0.130)***	(0.145)***	(0.129)***	(0.128)***	(0.121)***	(0.119)***
Income	0.063	0.032	0.085	0.044	0.053	0.045
	(0.032)**	(0.028)	(0.029)***	(0.032)	(0.029)*	(0.029)
Wage	-0.012	0.044	-0.197	0.074	-0.036	0.047
	(0.091)	(0.088)	(0.081)**	(0.082)	(0.099)	(0.094)
CON	0.454	0.031	-0.097	0.216	-0.038	0.312
	(0.179)**	(0.177)	(0.180)	(0.166)	(0.167)	(0.176)*
HMO	-0.012	0.006	-0.001	0.001	0.012	0.001
	(0.007)*	(0.007)	(0.006)	(0.008)	(0.006)*	(0.007)
White	-0.011	0.009	-0.005	-0.004	-0.001	0.001
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)
Older	-0.001	0.035	-0.075	-0.044	-0.011	0.007
	(0.028)	(0.029)	(0.030)**	(0.029)	(0.031)	(0.026)
Rent	-0.004	-0.004	-0.003	-0.006	-0.002	-0.003
	(0.002)***	(0.002)***	(0.002)*	(0.002)***	(0.001)*	(0.001)**
Nonprofit	-0.436	-0.262	0.179	0.504	0.141	-0.847
	(0.355)	(0.346)	(0.416)	(0.360)	(0.363)	(0.290)***
Obs.	219	219	219	219	219	219

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX TABLE 1 (CONTINUED): MAXIMUM LIKELIHOOD ESTIMATES USING ISOLATED MSAS AND COUNTIES

	Wellness Center	Pain Center	Women's Center	Neurological	Sleep Disorder	Lithotripsy
Population	1.236	1.257	1.329	1.399	1.363	1.678
	(0.134)***	(0.134)***	(0.170)***	(0.142)***	(0.146)***	(0.158)***
Income	0.052	0.065	0.070	0.083	0.092	0.042
	(0.031)*	(0.033)*	(0.033)**	(0.035)**	(0.033)***	(0.025)*
Wage	-0.148	-0.035	-0.179	-0.176	-0.148	-0.057
	(0.087)*	(0.087)	(0.092)*	(0.090)*	(0.084)*	(0.099)
CON	0.210	0.150	0.098	0.555	0.543	0.459
	(0.177)	(0.173)	(0.177)	(0.182)***	(0.179)***	(0.177)***
HMO	-0.001	-0.000	-0.000	-0.004	-0.018	-0.017
	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)***	(0.008)**
White	0.003	-0.001	-0.009	-0.002	-0.006	-0.001
	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
Older	0.074	0.050	0.060	0.027	0.030	0.037
	(0.029)***	(0.032)	(0.026)**	(0.025)	(0.028)	(0.026)
Rent	-0.003	-0.006	-0.005	-0.005	-0.006	-0.005
	(0.001)**	(0.002)***	(0.001)***	(0.001)***	(0.002)***	(0.002)***
Nonprofit	0.412	-0.308	-0.085	-0.456	0.485	0.152
	(0.365)	(0.346)	(0.378)	(0.312)	(0.367)	(0.337)
Obs.	219	219	219	219	219	219

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX TABLE 1 (CONTINUED): MAXIMUM LIKELIHOOD ESTIMATES USING ISOLATED MSAS AND COUNTIES

	Radiation Therapy	Reconstructive /Plastic	Sports Medicine	Hospice	Histopath-ology	Cardiac Catheterization Lab
Population	1.845	1.647	1.175	1.101	1.402	2.079
	(0.192)***	(0.141)***	(0.144)***	(0.127)***	(0.125)***	(0.217)***
Income	0.123	0.068	0.077	0.020	0.065	0.141
	(0.028)***	(0.030)**	(0.037)**	(0.025)	(0.024)***	(0.049)***
Wage	-0.163	-0.275	-0.031	0.115	-0.136	-0.481
	(0.093)*	(0.086)***	(0.093)	(0.083)	(0.104)	(0.099)***
CON	0.043	0.351	0.166	-0.032	0.194	0.228
	(0.184)	(0.174)**	(0.178)	(0.178)	(0.165)	(0.192)
HMO	0.004	-0.010	0.001	0.007	0.004	0.002
	(0.007)	(0.006)	(0.006)	(0.006)	(0.005)	(0.007)
White	0.008	-0.008	0.001	0.002	-0.006	-0.003
	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)	(0.008)
Older	0.035	0.069	0.012	0.025	0.090	0.035
	(0.025)	(0.021)***	(0.028)	(0.031)	(0.025)***	(0.027)
Rent	-0.008	-0.004	-0.005	-0.006	-0.005	-0.004
	(0.002)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.002)***
Nonprofit	0.483	0.148	-0.600	1.023	0.445	-0.997
	(0.414)	(0.397)	(0.276)**	(0.364)***	(0.367)	(0.332)***
Obs.	219	219	219	219	219	219

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX TABLE 1 (CONTINUED): MAXIMUM LIKELIHOOD ESTIMATES USING ISOLATED MSAS AND COUNTIES

	Skilled Nursing	Dialysis	Laser Ophthal-mology	Ophthal-mologic	Geriatric Services	Pediatric Services	Cardiology
Popu-lation	1.301	1.805	1.824	1.685	1.536	1.794	2.091
	(0.127)***	(0.147)***	(0.189)***	(0.157)***	(0.147)***	(0.148)***	(0.177)***
Income	0.015	0.123	0.088	0.051	0.031	0.073	0.104
	(0.026)	(0.033)***	(0.033)***	(0.031)*	(0.029)	(0.026)***	(0.033)***
Wage	-0.070	-0.156	-0.176	-0.018	0.042	0.027	-0.065
	(0.082)	(0.109)	(0.112)	(0.106)	(0.084)	(0.091)	(0.106)
CON	-0.345	0.138	0.396	0.325	0.053	0.232	0.295
	(0.162)**	(0.177)	(0.177)**	(0.155)**	(0.171)	(0.163)	(0.188)
HMO	0.006	0.001	-0.004	0.002	0.008	0.000	-0.001
	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)
White	0.008	-0.021	0.001	-0.007	0.005	-0.009	-0.005
	(0.007)	(0.007)***	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)
Older	0.073	0.084	0.046	0.054	0.020	0.042	0.074
	(0.028)***	(0.034)**	(0.026)*	(0.025)**	(0.029)	(0.033)	(0.033)**
Rent	-0.009	-0.009	-0.009	-0.007	-0.006	-0.008	-0.008
	(0.001)***	(0.002)***	(0.002)***	(0.002)***	(0.002)***	(0.001)***	(0.002)***
Non-Profit	-0.228	-0.474	-0.422	0.079	0.130	-0.573	-0.575
	(0.392)	(0.317)	(0.334)	(0.340)	(0.407)	(0.341)*	(0.372)
Obs.	219	219	219	219	219	219	219

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX TABLE 2: MAXIMUM LIKELIHOOD ESTIMATES USING ALL COUNTIES

	Oncology	Gastroent-erology	Ultrasound	Intensive Cardiac	Home Health
Population	1.156	1.012	0.563	0.903	0.643
	(0.043)***	(0.045)***	(0.036)***	(0.039)***	(0.035)***
Income	0.044	0.022	0.009	0.024	0.019
	(0.007)***	(0.007)***	(0.007)	(0.007)***	(0.007)***
Wage	-0.017	0.010	0.022	0.043	0.033
	(0.018)	(0.017)	(0.016)	(0.017)**	(0.016)**
CON	-0.063	-0.036	-0.110	-0.234	-0.403
	(0.060)	(0.059)	(0.056)**	(0.057)***	(0.055)***
HMO	0.007	0.009	0.002	0.000	0.003
	(0.003)***	(0.002)***	(0.003)	(0.002)	(0.003)
White	-0.000	-0.007	-0.004	-0.002	-0.003
	(0.002)	(0.002)***	(0.002)**	(0.002)	(0.002)*
Older	0.078	0.059	0.045	0.060	0.070
	(0.009)***	(0.008)***	(0.009)***	(0.009)***	(0.008)***
Rent	-0.002	-0.001	-0.001	-0.000	-0.001
	(0.000)***	(0.000)**	(0.000)**	(0.000)	(0.000)***
Nonprofit	0.050	-0.201	-0.095	-0.117	0.188
	(0.094)	(0.086)**	(0.078)	(0.084)	(0.084)**
Commute	-0.017	-0.004	-0.006	-0.028	-0.013
	(0.004)***	(0.004)	(0.004)	(0.004)***	(0.004)***
Obs.	2073	2073	2073	2073	2073

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX TABLE 2 (CONTINUED): MAXIMUM LIKELIHOOD ESTIMATES USING ALL COUNTIES

	MRI	Birth Room	Orthopedic Surgery	Labor/ Delivery	Nuclear Medicine
Population	1.059	0.801	1.113	0.880	1.262
	(0.041)***	(0.039)***	(0.045)***	(0.039)***	(0.043)***
Income	0.037	0.018	0.019	0.023	0.034
	(0.007)***	(0.007)***	(0.007)***	(0.006)***	(0.007)***
Wage	-0.001	-0.021	-0.031	-0.023	0.032
	(0.017)	(0.016)	(0.017)*	(0.016)	(0.017)*
CON	-0.307	-0.380	-0.118	-0.449	-0.234
	(0.057)***	(0.058)***	(0.058)**	(0.057)***	(0.060)***
HMO	0.001	0.001	0.007	0.002	0.002
	(0.003)	(0.003)	(0.003)***	(0.003)	(0.003)
White	-0.001	0.002	0.003	-0.002	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Older	0.052	0.037	0.045	0.044	0.081
	(0.009)***	(0.009)***	(0.008)***	(0.009)***	(0.009)***
Rent	-0.001	0.001	-0.001	0.000	-0.003
	(0.000)***	(0.000)**	(0.000)	(0.000)	(0.000)***
Nonprofit	-0.220	0.010	-0.144	-0.028	-0.173
	(0.092)**	(0.089)	(0.088)	(0.091)	(0.092)*
Commute	-0.029	-0.047	-0.023	-0.047	-0.018
	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***
Obs.	2073	2073	2073	2073	2073

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX TABLE 2 (CONTINUED): MAXIMUM LIKELIHOOD ESTIMATES USING ALL COUNTIES

	Intensive General	Ambulatory surgery	CT scan	ER	Respiratory
Population	1.229	0.925	1.162	0.913	1.069
	(0.050)***	(0.040)***	(0.047)***	(0.046)***	(0.047)***
Income	0.021	0.018	0.017	0.009	0.006
	(0.007)***	(0.007)***	(0.007)**	(0.008)	(0.007)
Wage	0.013	0.005	0.017	0.007	0.013
	(0.017)	(0.016)	(0.018)	(0.019)	(0.018)
CON	-0.193	-0.309	-0.271	-0.338	-0.213
	(0.058)***	(0.058)***	(0.062)***	(0.064)***	(0.061)***
HMO	0.006	0.008	0.007	0.010	0.007
	(0.003)**	(0.002)***	(0.003)***	(0.003)***	(0.002)***
White	0.003	-0.002	-0.002	-0.007	-0.006
	(0.002)	(0.002)	(0.002)	(0.002)***	(0.002)***
Older	0.057	0.067	0.071	0.077	0.061
	(0.009)***	(0.009)***	(0.009)***	(0.009)***	(0.009)***
Rent	-0.001	-0.001	-0.002	-0.001	-0.002
	(0.000)**	(0.000)**	(0.000)***	(0.001)**	(0.000)***
Nonprofit	-0.205	-0.137	-0.195	-0.239	-0.184
	(0.096)**	(0.089)	(0.097)**	(0.095)**	(0.098)*
Commute	-0.029	-0.020	-0.018	-0.022	-0.018
	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***
Obs.	2073	2073	2073	2073	2073

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%