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Is hospital competition wasteful?

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Recent attention has been given to the hypothesis that local hospital competition takes the form of costly duplication of specialized services—the "medical arms race." This contrasts with the hypothesis that the supply of specialized services is determined solely by "the extent of the market." We develop a model predicting the provision of specialized services in local markets. Our analysis of California hospitals provides minimal support for the medical arms race hypothesis while suggesting substantial scale economies for many services. Our results emphasize the importance of properly specifying the extent of the market. Failure to do so leads one to overestimate the importance of competition.

1. Introduction

■ It is frequently asserted that consumers do not benefit from competition among hospitals (Robinson and Luft, 1985; Kopit and McCann, 1988; McLaughlin, 1988; and McManis, 1990). Hospital competition is allegedly wasteful, leading to higher costs without commensurate benefits. This wasteful competition is colloquially referred to as the "medical arms race" (henceforth, MAR). According to the MAR hypothesis, hospitals compete by providing too many high-tech medical services. Duplication of capital-intensive services raises the costs of care. At the same time, unnecessary duplication of services may cause the quality of care to fall as providers fail to take advantage of scale and learning effects (Luft et al., 1986).

A direct implication of the MAR hypothesis is that competition among hospitals is bad. This argument is of more than academic import. It has been embraced by the media, has motivated recent calls to nationalize the provision of hospital services, and has played a prominent role in recent hospital antitrust decisions. For example, the MAR hypothesis was a key factor in the Fourth Circuit's decision to permit a merger between the two largest hospitals in Roanoke, Virginia (a three-hospital town). In his decision, the district court

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judge wrote, "As a general rule, hospital rates are lower, the fewer the number of hospitals in an area" (*United States* v. *Carilion Health System,* 892 F 2d 1042). Similar arguments emerged in an Augusta, Georgia, merger case (*FTC* v. *University Health Inc. and Health Care Corporation of Sisters of St. Joseph,* No. CV 191-052).[1] While the MAR hypothesis is commonly accepted in the health industry, it completely reverses traditional economic thinking about the salutory effects of competition.

This article reexamines the empirical evidence for the MAR. We contrast the MAR against the simple economic proposition that the number of providers of a particular high-tech service will be determined by the extent of the market. We ask two basic questions: First, controlling for the extent of the market, does the MAR matter on the margin? Second, is the magnitude of the MAR sufficient to warrant policy interest?

We identify 11 high-tech hospital service categories that may be associated with the MAR. We then estimate the empirical relation between the number of providers in a market, supply and demand factors, and competitive structure. We reach the following conclusions:

(1) There is an identifiable MAR effect, significant at $p < .10$, when the results are evaluated jointly across the 11 specialized services.

(2) The MAR has a small economic effect. A merger of the size considered in *Carilion* is not predicted to reduce capital outlays.

(3) Separating the MAR effect from the effect of the extent of the market is a difficult econometric problem. The MAR effect arises from the degree of competition. Competition is instrumented by market structure, and market structure is endogenous to the extent of the market. Prior empirical estimates of the MAR do not recognize this endogeneity. We cannot eliminate the endogeneity problem, but we can better bound the resulting bias.

(4) The extent of the market matters. Not only does local population predict the patterns of service provision, but so too do proximate population and distance to markets offering potentially competing services.

(5) The patterns of service provision in markets of different sizes are broadly consistent with those identified by Bresnahan and Reiss (1991) in their analysis of consumer services. In particular, the population increments needed to support additional suppliers continually rise as the number of suppliers rises from one to four. Bresnahan and Reiss point out that such a pattern indicates oligopolistic pricing. For hospital markets, we reject their interpretation of such a pattern in favor of one emphasizing scale and scope economies.

2. The medical arms race

■ In theory, quality may be over- or underprovided by sellers in competitive markets, depending on such factors as the difference between the marginal and average value of quality as perceived by consumers (Spence, 1975) and the observability of quality differences across providers (Dranove and Satterthwaite, 1992). The MAR hypothesis is a special case of quality competition, in which it is asserted that quality is overproduced in competitive markets. An alternative explanation that we do not explore is that quality is underprovided in monopoly markets. The seminal statement of the MAR hypothesis appears in Robinson and Luft (1985), who contend that hospitals in more competitive markets provide duplicative services, i.e., services in excess of what would be demanded by the market. The intuition behind the MAR hypothesis is that hospitals compete for physicians, who in turn determine admission patterns. Robinson and Luft assert that hospitals can attract physicians by offering the latest technologies, regardless of existing supply and expected utilization.

[1] The Roanoke decision was upheld on appeal: the Augusta decision was reversed.

The MAR hypothesis has some intuitive merit. Hospitals have historically competed on the basis of quality (Jacobs, 1974). Hospitals may raise quality to attract patients directly or indirectly, through their primary care physicians. Physicians may be quality sensitive, especially if the quality of hospital services is a substitute for their own time. To the extent that patients have health insurance, their concerns about the cost of high quality are attenuated. For these reasons, we do not directly challenge the theoretical basis for the MAR. We do challenge the empirical evidence supporting the MAR hypothesis and the central role it occupies in recent discussions of hospital competition.

Robinson and Luft's theoretical focus is on the provision of specialized services; however, their empirical analysis looks at costs. Hospitals in close proximity are more costly than hospitals with few surrounding competitors. Similar findings appear in Luft et al. (1986), Robinson (1988), Robinson et al. (1988), Noether (1988), and Zwanziger and Melnick (1988). The general inference is that higher costs arise from service duplication in more competitive markets.[2]

We question the econometric evidence supporting the MAR hypothesis on three grounds. First, the MAR hypothesis speaks to the duplication and subsequent underutilization of specific services, yet most of the empirical work focuses on costs. Second, inadequate attention is paid to market definitions. Third, scale and scope economies are not explored as alternative explanations for the observed differences in costs and specialized service supply across markets.

3. Modelling the supply of specialized services

■ The fundamental question we ask is, What determines the number of providers of specialized services in local markets? This is precisely the question addressed by Bresnahan and Reiss (1991). Bresnahan and Reiss look at a number of professional and quasi-professional services, including dentists, hair stylists, and car dealers. We look at specialized hospital services.

Following Bresnahan and Reiss, we posit that supply and demand factors will be important determinants of the number of sellers of specialized hospital services. We augment Bresnahan and Reiss by asking whether competition between hospitals is also a determinant of service supply.

For each specialized service, i, in each market, j, we can write

$$N_{i,j} = f(\text{Demand Shifters, Supply Shifters, Competition}), \tag{1}$$

where $N_{i,j}$ is the number of providers of service i in market j.

The categorical dependent variable $N_{i,j}$ is estimated using an ordered probit model. The probit specification generates an ordinal measure of the level of specialized service availability. The number of providers in each market is treated as a categorical variable with $\mathbf{M}$ response categories, $m_1, m_2, \ldots m_M$. For example, if we observe at most two providers of a specific service in any market, the categories $\{m_1, m_2, m_3\}$ naturally correspond to $N = 0$, $N = 1$, $N = 2$.

The observed response is conditional upon the independent variable set, i.e., upon supply, demand, and competition. Specifically,

$$\begin{aligned} N_{i,j} &= m_1 \quad \text{if} \quad \mathbf{X}\beta < \mu_1, \\ N_{i,j} &= m_2 \quad \text{if} \quad \mu_1 < \mathbf{X}\beta < \mu_2, \quad \text{and} \\ N_{i,j} &= m_3 \quad \text{if} \quad \mu_2 < \mathbf{X}\beta. \end{aligned}$$

[2] Noether (1988) does not draw normative inferences from her results. Zwanziger and Melnick (1988) document a strong medical arms race effect through 1983 that diminishes in subsequent years.

Let the cumulative normal distribution be denoted by $\mathbf{F}(\cdot)$ and let $\mu_1 = 0$. Then,

$$\Pr[m_k] = \mathbf{F}[\mu_k - \mathbf{X}\beta] - \mathbf{F}[\mu_{k-1} - \mathbf{X}\beta].$$

Maximum likelihood estimation yields the parameters $\mu_1 \ldots \mu_{m-1}$ and the coefficient vector $\boldsymbol{\beta}$.

The ordered probit model has the following intuition. The values of $\mathbf{X}\beta$ may be thought of as "packets of supply and demand." The μ's may be thought of as "thresholds." If $\mathbf{X}\beta$ exceeds a particular threshold, then we predict that the market will have the number of providers associated with that threshold.

Since the observed values of N are assumed to reflect an ordinal ranking, there is no *a priori* significance attached to the magnitude of the distance between the N's. Thus, three local suppliers of a service reflect higher levels of market demand than do two suppliers, but not necessarily 50% higher. The μ's are free parameters that permit us to estimate a highly flexible (monotonic) relationship between observed $\mathbf{X}\beta$ and the thresholds at which additional services are supported.

Ordered probit offers additional benefits over standard regression models.[3] First, because it fits ordinal categories, probit does not overweight either the abundance of small markets or extreme values associated with very large markets like Los Angeles or San Francisco. In fact, services in markets at the extreme ends of the size spectrum are explained relatively well solely by local population when one employs linear or log-linear regression models. Intermediate-size markets, however, are of the greatest economic interest. By overfitting the extremes, regression analysis introduces systematic biases in the intermediate range.

Second, ordered probit estimates are more robust to model specification than are the analogous regression results. McKelvey and Zavoina (1975) show that when regression analysis is employed with a categorical dependent variable, correlation is induced between the error term and the independent regressors. This causes a bias that is dependent on the distribution of the independent variables. The resulting regression coefficients are biased.

Finally, in addition to providing information about the structural importance of right-hand-side variables, ordered probit permits us to extract information about competitive behavior and/or scale and scope economies. This information is embodied in the interval thresholds $\boldsymbol{\mu}$. For example, consider the finding by Bresnahan and Reiss (1991) that the difference between μ's grows progressively larger from μ_1 through about μ_4 and then stabilizes. (That is, the "demand packet" necessary to support two sellers is more than twice the size of the demand packet necessary to support one seller.) They infer that as the number of sellers in a market increases from one to four, they become more price competitive, causing profit per unit to fall. Competition is achieved—prices fall and firms are forced to operate at efficient scale—with four or more sellers in Bresnahan and Reiss's markets. Alternatively, holding prices constant, the interval thresholds suggest patterns of scale and scope economies. A fringe benefit of our analysis of the MAR hypothesis is in contributing more generally to the literature relating the number of sellers and level of competition to characteristics of local markets.

4. Defining markets

■ A critical first issue is the definition of the local market. There are a number of alternative approaches to defining markets. When correctly defined, a market should include all buyers and sellers whose interactions determine the price. A simple ad hoc approach is to use government-defined geographic boundaries, such as cities. There is no reason to believe that

[3] Results were also estimated using Poisson regression techniques. In general, the assumptions of the Poisson model are excessively restrictive: (1) the occurrence of a second supplier is not independent of the existence of the first, and (2) the assumption that the conditional mean and variance are equal was violated in all of the service categories—the variance significantly exceeds the mean.

these boundaries constitute economic markets. A more sophisticated approach is to examine patient flow data; markets are well defined when they have relatively low inflows and outflows (Elzinga and Hogarty, 1978).[4] There are many reasons to suspect that the markets defined on the basis of flows may understate or overstate the true size of the market (Stigler and Sherwin, 1985; Baker and Bresnahan, 1988; Werden, 1990; and Zwanziger, 1990).

Lack of attention to market definition has confounded measurement of the MAR hypothesis in previous studies. Consider the analysis of Robinson and Luft (1985). The degree of competition facing a given hospital is measured by the number of hospitals within 15 miles of that hospital.[5] Other predictors include population density and several measures of the hospital's characteristics.

There are two interrelated problems with this specification: (1) the market boundaries are generally too small, and (2) the proxy for competition, the number of hospitals, is endogenous. A positive coefficient on the competition variable can represent higher costs due to the MAR and/or the effects of correlated but omitted determinants of the extent of the market.

We recognize that no market definition is likely to be accurate for all markets. The definition we will employ is no exception. We begin with a definition we believe generally understates hospital market size (Dranove and Shanley, 1990). We augment our markets by including the predictive model two variables that proxy for potential patient flows.[6]

Specifically, we choose as local markets all urbanized areas[7] and all cities with populations greater than 5,000 not in an urbanized area.[8] We identify a total of 103 local markets, with 445 community hospitals. As our interest is in measuring competitive effects, we exclude 16 markets in which there are no hospitals, leaving us a sample of 87 local markets. The hospitals in these markets accounted for 98% of all the community hospitals in California and all but one of the community hospitals with over 100 beds. (Hospitals with fewer than 100 beds are considered small and usually do not offer specialized services.) A complete list of markets, along with demographic and geographic information, is available from the authors upon request.

Our methodology directly accommodates the possibilities of patient flows to and from proximate geographic areas. For each of the local markets we include variables to proxy for fringe supply and fringe demand. As the impact of fringe supply and fringe demand may vary by service, we allow the fringe supply and fringe demand coefficients to vary for each service. The definitions of fringe supply and fringe demand are given below.

□ **Service identification.** We used 1983 data from the California Office of Statewide Health Planning to identify providers of specialized hospital services. Our time period was chosen

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[4] Both price correlation analysis (Stigler and Sherwin, 1985) and residual demand curve estimation (Baker and Bresnahan, 1988) have severe data requirements and may still leave some doubt about the correct sizes of markets.

[5] See Dranove and Shanley (1990) for a detailed critique of the "15-mile radius" market definition. Noether (1988) uses the standard metropolitan statistical area (SMSA), and Zwanziger and Melnick (1988) use a narrow definition based on patient flows. Both Noether and Zwanziger and Melnick measure competition with a Herfindahl.

[6] The only markets that we suspect may be too big are Los Angeles and San Francisco. We lack a defensible methodology for breaking these cities into submarkets. Note that the ordinal nature of the probit model assures us that this shortcoming will have minimal impact on our results. Results are virtually unaffected by excluding Los Angeles and San Francisco from the analysis.

[7] Typically, an urbanized area consists of a central city and all contiguous zip codes with population densities exceeding 1,000 per square mile. Generally speaking, SMSAs encompass one or more urbanized areas.

[8] Included in any city's markets are any identifiable towns or census-designated places within ten miles of the city. Our city definitions are hierarchical in the sense that if a city was within a larger city's urbanized area or ten-mile radius, it was included in the larger city's market and not considered independently. Note that we exclude South Lake Tahoe, both because it is contiguous with a population center in Nevada and because it has an exceptionally high proportion of tourists relative to its population.

to provide the greatest degree of comparability with previous research that has documented the MAR.

Each hospital in the state is required to report the presence or absence of 171 hospital services. For obvious reasons, we do not individually analyze all 171 services. From the service inventory we identify first a subset of distinctive high-tech services associated with the MAR. These are: open-heart surgery, full-body CT scans, radiation therapy, and radio-isotope therapy. Each of these has substantial fixed costs, so that unnecessary duplication of any of these services would be economically wasteful.

Remaining services are defined at a level that is not readily associated with the provision of distinctive services: in many cases the survey's definition of the "service" is too narrow to be analyzed independently; in a few cases, the service definition is too broad. We deal with this problem in the following fashion. First, we eliminate services that are either so basic that virtually all hospitals provide them or are available from nonhospital providers. Second, we aggregate the remaining services into seven groupings that may be defined along clinical or technological lines: cardiology, deliveries, diagnostics, emergency, neonatology, pediatrics, and teaching. Details of our aggregation procedure are available from the authors upon request.

Given the service groupings, we must identify hospitals that qualify as specialized providers. Most hospitals offer some services in most of the groupings. We define specialized providers to be those hospitals offering the most extensive array of services in each group. In general, only 30% to 40% of all hospitals are classified as specialized providers of a given service. For example, although nearly every hospital has an emergency room, we identify just one-third of the hospitals as "specialized" providers of emergency services. These hospitals would also have a trauma center or possibly a helicopter service.

It is important to point out that our measures indicate the presence or absence of services, not the quality of the service or the intensity of its use. We have no quality variables. The intensity variables in our data are limited to neonatology and open-heart surgery.[9]

□ **Dependent and independent variables.** We analyze specialization in each of 11 service groups. The unit of analysis is the market. The dependent variable N_{ij} is the number of hospitals in market i that are defined to be a specialized provider of service j.

Our independent variables measure the extent of the market and the cost of providing services. The independent variables specific to local demand are *POP,* defined to be the natural log of local population, and *INCOME,* defined to be the mean family income. Both variables are determined from the 1980 census. A log transformation is employed for *POP* because it affords a slightly better fit. Results are insensitive to the log transformation. In order to control for differences in variable costs (especially labor costs) across markets, we include *LABORCOST,* defined to be the average expenditure for aides and orderlies per bed in thousands of dollars. Unlike nurses wages, for example, the wages of aides and orderlies are likely to be independent of quality differences between hospitals. Labor inputs may be complements or substitutes to specialized services; hence, the sign on *LABORCOST* is an empirical issue. We have no measure of local capital costs, but we posit that capital costs should not vary significantly within the state.

The variables for fringe supply and demand require special consideration. If markets are underspecified, then patients flow to and from fringe areas. If fringe supply and demand are significant, they will affect local service provision. Absent a perfect market definition, correct specification requires inclusion of measures of nearby population (fringe demand)

[9] Analysis of the intensity data yields results consistent with those reported below. Neonatology and open-heart surgery are more intensively utilized in more populous markets, on a per-hospital basis. Market concentration is unrelated to utilization. This is inconsistent with the MAR, which would predict higher utilization in more concentrated markets.

and nearby service availability (fringe supply). We define our fringe demand measure, *FRINGEPOP,* as follows. For any given market Y, *FRINGEPOP* is the log of the total population of all other markets X, such that X has the following characteristics: (1) X is less populous than Y, and (2) of all markets more populous than X, Y is the closest. We define our fringe supply measure, *DISTANCE,* as follows. For urbanized areas, *DISTANCE* is the log of the mileage to the nearest more populous urbanized area. For nonurbanized areas, it is the log of the distance to the nearest urbanized area.[10] For services for which patients can travel to receive care (i.e., not for emergency services), the coefficients on both *DISTANCE* and *FRINGEPOP* should be positive. We expect that the magnitude of the coefficient will decline as the cost of travel increases.

Our rationale for the chosen fringe instruments has three components. First, *ceteris paribus,* individuals attempt to minimize transit costs. This point is supported by McGuirk and Porell (1984) and Dranove, White, and Wu (1991), who find that distance is an important determinant of hospital choice. Second, when patients cannot fill their health care needs within their own markets, they will travel to the nearest market that does meet their needs. This will generally be a more populous market. Consistent with this idea, our data on patient flows show that patients who do travel seek out more populous markets.[11] These flows from smaller to larger markets comprise the fringe demand for services in larger markets.

Third, the provision of specialized services in local markets is determined by a hierarchical ordering based largely on local population. A cursory examination of the data substantiates this assumption. The assumption implies that if a monopoly hospital in a small market is considering offering a service, then competitive suppliers will be found only in larger markets.

Our final predictor is a measure of competition, the Herfindahl index (*HERF*). We base our computation of the Herfindahl on patient discharges.[12] We identified ten markets in which hospitals shared common ownership. Commonly owned hospitals in a market are treated as a single firm for purposes of calculating the Herfindahl.

We may write our model as follows:

$$N_{i,j} = \beta_0 + \beta_1 POP + \beta_2 FRINGEPOP + \beta_3 DISTANCE + \beta_4 INCOME + \beta_5 LABORCOST + \beta_6 HERF. \quad (2)$$

Table 1 presents summary statistics for each of the independent variables. Unlike Robinson and Luft (1985), Noether (1988), and Zwanziger and Melnick (1988), we do not include measures of hospital characteristics, such as size, case-mix, or ownership type, as these are endogenous. With the exception of *HERF,* our predictors are exogenous.

We recognize the endogeneity of *HERF.* The MAR effect arises from the degree of competition. We instrument competition by *HERF,* a conventional measure of market structure. Market structure, in turn, is endogenous to the extent of the market. Thus, the coefficient of *HERF* may pick up any omitted variables associated with the extent of the

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[10] We used the *1989 Rand McNally Road Atlas* to determine highway distances between cities. When possible, we used interstate highway miles. The value of *DISTANCE* for Los Angeles was the distance to San Francisco. Our logic was that this was the only market offering an array of services fully competitive with those offered in Los Angeles. For alternative distance measures, we tried distance to the nearest market with a teaching hospital and distance to the closer of San Francisco or Los Angeles. Neither measure proved as powerful a predictor as distance to the nearest larger urbanized area.

[11] The main exceptions are Los Angeles, San Diego, and San Francisco, for which outflows tend to be relatively low. These are the "exceptions that prove the rule"—patients in these markets have no reason to travel because no better care can be found elsewhere.

[12] This definition is consistent with Noether (1988) and Zwanziger and Melnick (1988). An alternative measure of the Herfindahl-index-based capacity (beds) was also computed. The two measures were very highly correlated.

TABLE 1 Descriptive Statistics for Independent Variables

Variable	Mean	Median	Standard Deviation	Range
POP[a]	2.05	.31	9.4	.01 to 94.8
FRINGEPOP[b]	.42	.09	1.2	.005 to 11.6
DISTANCE	47.4	22	38.6	8 to 376
INCOME (000's)	1.92	1.8	.29	1.4 to 3.0
JANCOST[c]	3.17	2.7	1.44	0.6 to 8.7
HERF	74	100	30	3 to 100

[a] Population in 100,000s. Variables were scaled such that the independent variable set was of approximately the same magnitude. This increases the efficiency of the nonlinear ordered probit estimation techniques.

[b] Fringe population in 100,000s. Markets with no fringe population were coded as .01.

[c] Average expenditures on janitors, aides, and orderlies per bed. In $1000s.

Sources: Census of the Population, 1980 (*POP, FRINGEPOP, INCOME*); *Rand McNally Road Atlas of California* (*DISTANCE*); California Office of Statewide Health Planning and Development (OSHPD); Annual Financial Disclosure Reports (*JANCOST, HERF*).

market. Separating the MAR effect from the effect of the extent of the market is a difficult econometric problem. We are unable to identify an exogenous variable associated with the demand for hospitals yet independent of the demand for hospital services. However, by adjusting *HERF* to account for common ownership of hospitals within markets, and by considering the geographic relationship of local markets, we are able to demonstrably reduce the bias.

We are also aware that colinearity reduces the precision with which we can estimate model coefficients. We have, however, verified that the results reported below are robust with respect to model specification.[13] The MAR effect arises from the degree of competition. Lacking any defendable alternative, competition is instrumented by market structure, and market structure is endogenous to the extent of the market. The correlation between *HERF* and the log of *POP* is almost .7.[14] Colinearity is reduced by treating commonly owned hospitals as a single firm in computing the Herfindahl.

4. Results

■ Table 2 presents the ordered probit estimates of the model coefficients for each service. The last row indicates, for each independent variable, whether the average coefficient across the 11 service categories is positive or negative, and whether it is jointly significant under the assumption that the services are independent.

As seen in Table 2, the coefficients on *POP* in the individual regressions are positive and significant for all services. An increase in local population leads to increases in the local supply of specialized services. The coefficients on *FRINGEPOP* are almost always positive and generally significant. Fringe regions contribute significant patient flows. The magnitude of the draw differs depending upon the service, and in most cases it should be weighed less than local factors when assessing resource supply.

Coefficients on *DISTANCE* are usually positive but generally not significant. The positive coefficients on *FRINGEPOP* and *DISTANCE* imply that fringe demand and fringe supply influence resource availability in a manner consistent with the theory.

[13] Results using alternative specifications are available from the authors.

[14] The correlation between *HERF* and *POP* is .45.

TABLE 2 Probit Results: Demand Coefficients

Service	*POP*	*FRINGEPOP*	*DISTANCE*	*INCOME*	*JANCOST*	*HERF*
Cardiology	.741[c]	.217	.078	−.148	.033	−.009
	(2.40)	(1.57)	(.32)	(−.17)	(0.13)	(−.07)
Deliveries	.503[c]	.119[a]	.149	−.541[a]	.119	−.010
	(2.92)	(1.69)	(.70)	(−1.81)	(.71)	(−.22)
Diagnostics	1.430[c]	.078[a]	.166	−.580	.196	−.018[a]
	(4.34)	(1.60)	(.43)	(−.93)	(.78)	(−1.63)
Emergency	.319[a]	.036	−.114	.550	−.222	−.016[b]
	(1.83)	(.07)	(−.05)	(.95)	(−1.44)	(−2.14)
Neonatology	.779[c]	.166[a]	.125	−.149	−.104	−.008
	(3.07)	(1.87)	(1.12)	(−.44)	(−.58)	(−.49)
Pediatrics	.689[c]	.109[a]	.416[a]	.389	.057	−.016
	(3.85)	(1.83)	(1.65)	(.85)	(.44)	(−1.04)
Teaching	3.91[a]	−.223	.564	−.229	−1.66	.007
	(1.83)	(−.52)	(1.31)	(−.08)	(−.89)	(.11)
CT scans	.708[a]	.077	.132	.118	−.210	−.017
	(1.94)	(.56)	(.39)	(.19)	(−.74)	(−1.30)
Open-heart surgery	.841[a]	.066	−.088	1.50	.449	−.023
	(1.99)	(.92)	(−.09)	(1.14)	(.065)	(−.48)
Radiation therapy	.674[c]	.063	.413[a]	.190	.008	−.006
	(2.44)	(.44)	(1.84)	(.26)	(.03)	(−.55)
Radioisotope therapy	1.518[c]	.295[a]	.032	−.347	.129	−.008
	(2.69)	(1.77)	(.10)	(−.26)	(.51)	(−.89)
Joint test	+[c]	+[b]	+[b]	0	0	−[a]

[a] Significant at $p < .10$.
[b] Significant at $p < .05$.
[c] Significant at $p < .01$.
Note: These coefficients are obtained from ordered probit estimates. The dependent variables were obtained from OSHPD; the independent variables are described in Table 1. t-statistics are in parentheses.

In the "exception that proves the rule," *FRINGEPOP* and *DISTANCE* are least important in determining local provision of emergency services. This makes sense because travel for these services is prohibitively costly.

Joint tests on both *FRINGEPOP* and *DISTANCE* suggest that the pattern of positive coefficients is not due to chance—the joint tests are significant at $p < .05$. There is no consistent pattern for the coefficients on *INCOME* and *LABORCOST*.

Greater competition, as measured by lower values of *HERF*, generally increases service availability. The individual coefficients are generally insignificant, but the joint test is significant at $p < .10$. Thus, we find some support for the MAR hypothesis.

□ **The bias on *HERF* when *FRINGEPOP* and *DISTANCE* are omitted.** Table 3 reports the estimated coefficients on *HERF* for the full model (i.e., the model presented above) and for an underspecified model that excludes our measures of fringe supply and demand. For every service, underspecifying the extent of the market imparts a negative bias to the *HERF* coefficient. In most cases, the coefficient on *HERF* becomes statistically significant. This is consistent with our earlier discussion that inadequate specification of the extent of the market generates an omitted variable bias in favor of the MAR hypothesis.

This finding has an important implication. Prior studies of hospital competition have not addressed the geographical extent of local markets. We can speculate that the underspecified markets used in the incumbent literature are subject to the same biases noted above. To the extent that we do not fully specify the extent of the market, our estimate on

TABLE 3 **Bias in *HERF* When *FRINGEPOP* and *DISTANCE* are Omitted**

Service	Full Model	*FRINGEPOP* and *DISTANCE* Omitted	Bias
Cardiology	−.009	−.016[a]	−.007
Deliveries	−.010	−.017[a]	−.007
Diagnostics	−.018[a]	−.022[b]	−.004
Emergency	−.016[a]	−.017[b]	−.001
Neonatology	−.008	−.013[a]	−.005
Pediatrics	−.016	−.021[a]	−.005
Teaching	.007	−.005	−.012
CT scans	−.017	−.019[a]	−.002
Open-heart surgery	−.023	−.026	−.003
Radiation therapy	−.006	−.017[a]	−.011
Radioisotope therapy	−.008	−.009	−.001

[a] Significant at $p < .10$.
[b] Significant at $p < .05$.
[c] Significant at $p < .01$.
Note: The first column reports the coefficients on *HERF* from the ordered probit in Table 2. The next column reports the coefficients on *HERF* when the ordered probit is reestimated without the variables *FRINGEPOP* and *DISTANCE*. The last column is just the difference between the previous two.

the importance of market structure is biased as well. One implication is that our results may reflect an upper bound on the importance of the MAR effect.

□ **Is the MAR important?** A full analysis of the importance of the MAR would require detailed information on the costs and benefits of changes in the availability of medical services. We offer a starting point for such an analysis by evaluating the extent to which the MAR induces an economically significant quantity response.

Table 4 examines the effect of a one-standard-deviation change in the value of each of

TABLE 4 **Effect of a One-Standard-Deviation Increase in the Independent Variables on the Number of Services in a Market**

Service	Mean Providers[a]	*POP*	*FRINGEPOP*	*DISTANCE*	*INCOME*	*JANCOST*	*HERF*
Cardiology	1.9	1.0	.5	0	0	0	0
Deliveries	2.0	1.0	.5	0	0	0	−.5
Diagnostics	2.2	1.5	.5	0	0	.5	−.5
Emergency	1.6	0.5	0	0	0	0	−.5
Neonatology	2.1	1.5	.5	0	0	0	0
Pediatrics	.91	1.0	0	.5	0	0	0
Teaching	.70	1.5	0	0	0	−.5	0
CT scans	1.8	1.0	0	0	0	0	0
Open-heart surgery	1.4	1.0	0	0	.5	.5	0
Radiation therapy	1.2	0.5	0	.5	0	0	0
Radioisotope therapy	1.7	1.0	.5	0	0	0	0

Note: Marginal effects computed holding all independent variables at their mean values. Rounded to nearest one-half service provider.
[a] Mean number of specialized providers per service per market.

the independent variables on the predicted number of specialized services in a market.[15] Marginal effects are computed holding all other independent variables constant at their mean values. The reported figures have been rounded to the nearest one-half provider. Thus, a zero indicates that the change in the number of providers is less than .26.

The results in Table 4 are striking. *POP* matters a lot, and *FRINGEPOP* matters a little. Little else matters. In particular, a one-standard-deviation change in *HERF* is not predicted to affect resource supply. The standard deviation of *HERF* is .30. This exceeds the Herfindahl change that would have resulted from the Roanoke and Augusta mergers, or from mergers in most three- to four-hospital markets. Even so, we find that a one-standard-deviation rise in concentration would result in at most a .5 increase in service provision for only 3 of the 11 services: deliveries, diagnostics, and emergency room.

Our intuition regarding the relative unimportance of the MAR can be seen more directly by looking at the relationship between the supply of specialized services per capita and the number of hospitals in a market. We have plotted this relationship in Figure 1 for three representative services: cardiology, diagnostics, and neonatology.[16] If the MAR was the dominant determinant of specialized service supply, then we would expect these plots to show a general upward trend—as more hospitals appeared in a market, competition would drive them to add services beyond the level demanded by the population. In fact, the plots show a downward trend. This suggests that as markets grow and more hospitals enter, the dominant effects are probably scale and scope economies, with the MAR having its effect only on the margin.

□ **The pattern of entry of specialized providers in local markets.** We can use the probit results to investigate the pattern of entry in hospital markets as a function of demand. Table 5 reports the minimum population necessary to support increasing levels of service in a market.[17] For example, in the case of cardiology, the first specialized provider enters when the local population is roughly 62,000. A second provider enters at a population of 277,000. Additional providers enter with population increments of 680,000 to 830,000.

Three patterns of increments are evident in Table 5:

(1) Increments increase until the number of providers equals three or four and then appear to level off (cardiology, neonatology, pediatrics, and radiation therapy).

(2) Increments increase throughout (deliveries, diagnostics, emergency room, radioisotope therapy).

(3) Increments level off after the second provider (teaching, CT scan, open-heart surgery).

It is interesting to compare these patterns with those observed by Bresnahan and Reiss (1991) for a variety of professional and quasi-professional services. They generally observe pattern (1). They also point out that both patterns (1) and (2) would be indicative of oligopolistic pricing. They argue that if the dominant determinant of entry was scale economies rather than oligopolistic pricing, then pattern (3) would emerge. Since pattern (3) is

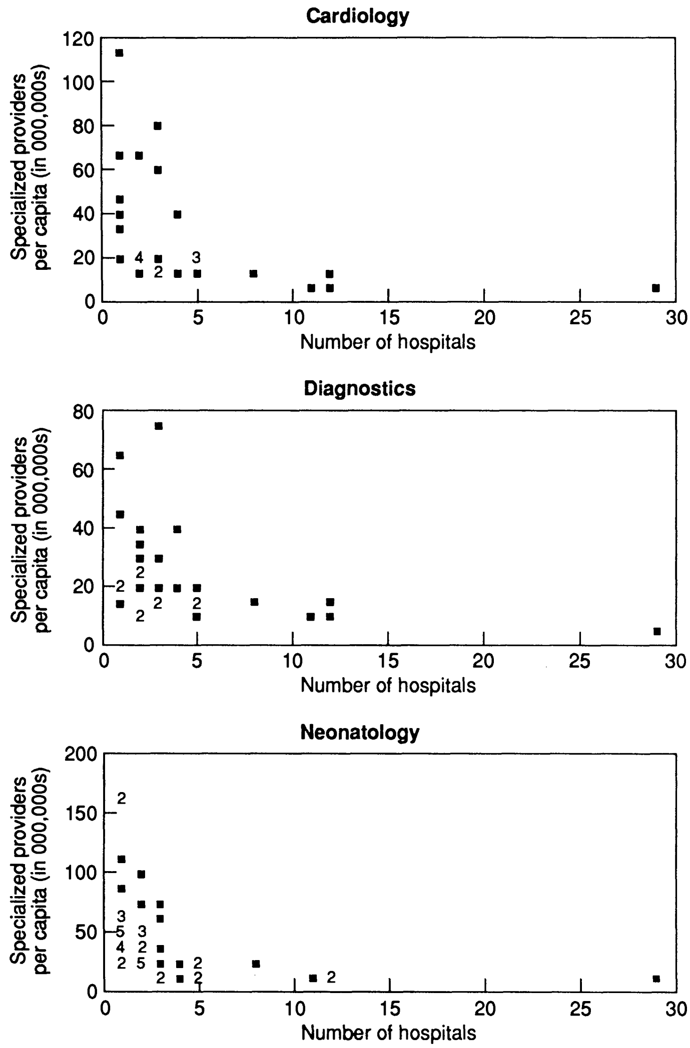
[15] Recall that the ordered probit generates a set of μ's that are interpreted as threshold values for ordinal service levels. We define an increase of one provider to occur when the change in $X\beta$ crosses over a μ threshold. If a change in $X\beta$ does not cross a μ threshold, then we interpolate to estimate the fraction of the distance travelled to the nearest threshold.

[16] For presentation purposes, we omitted from the figures all markets with no specialized providers, as well as San Francisco and Los Angeles.

[17] These estimates are based on coefficients from equation (4). Given the estimated threshold values, μ_i, we estimate the level of population necessary for $\mathbf{X}\beta$ to cross each threshold level. All variables except *HERF* are held at their mean values. Conditional mean values for *HERF* are employed—e.g., to compute the level of *POP* necessary to support one open-heart surgery unit, we use the mean of *HERF* conditional on OHS = 1.

FIGURE 1

SPECIALIZED PROVIDERS PER CAPITA BY NUMBER OF HOSPITALS



NOTE: Numbers in figures indicate multiple observations.

evident for only a few of our services, we are tempted to accept that the patterns are explained by oligopolistic pricing.

An alternative explanation for our observed patterns is that there are simultaneous scale and scope economies. For example, suppose there are scope economies in the provision of specialized cardiology and diagnostic services. That is, there are efficiencies in the joint production of these services. Efficiencies may arise from shared personnel, equipment, knowledge, etc. Suppose further that two hospitals in the same market currently offer only specialized diagnostic services. As the market grows, both hospitals may add specialized cardiology services. Scope economies enable them to expand diagnostic services at relatively low cost. This has the effect of increasing the population increment necessary to attract a third provider of specialized diagnostic services. From an empirical perspective, this may have the appearance of reducing the threshold necessary to support additional cardiology services.

TABLE 5 Population Necessary to Support *N* Services Per Market (in 1000s)

	Number of Services				
Service	1	2	3	4	5
Cardiology	62	277	974	1653	2482
Deliveries	19	158	377	*	1881
Diagnostics	46	101	204	328	508
Emergency	19	458	1180	2171	*
Neonatology	25	130	476	*	1014
Pediatrics	84	481	1026	*	2001
Teaching	87	240	395	*	*
CT scan	66	232	*	529	779
Open-heart surgery	96	490	889	*	1631
Radiation therapy	145	501	885	*	2061
Radioisotope therapy	45	281	499	856	*

* No observations for this service level.

The correct unit of analysis for identifying scope economies is the individual hospital. Even so, examination of a market-level pattern of service offerings provides some insight into the possible existence and configuration of scope economies. Our approach is to correlate market-level residuals from OLS prediction equations for each service (there are no meaningful residuals from ordered-probit analysis). We postulate that a positive correlation is consistent with some pattern of scope economies, assuming that hospitals seek to combine services efficiently.[18] Correlation results appear in Table 6.

Several patterns are apparent in Table 6. The correlations are uniformly positive. There appear to be certain groups with high intercorrelations. For example, the high intercorrelation between deliveries, pediatrics, and neonatology suggests that when one of these services is "overprovided," the others are overprovided as well.

A varimax factor analysis of the correlations in Table 6 identifies three underlying groups of services. The first group comprises (in decreasing order of the magnitude of loadings) open-heart surgery, diagnostics, CT scans, cardiology, radioisotope therapy, and (with substantially lower loadings) radiation therapy and teaching. The second comprises deliveries, pediatrics, and neonatology. Emergency room services stand alone as a third factor.

This analysis suggests that services are unlikely to be provided independently of each other. Further, the groupings are intuitively plausible. All the services in the first group are technologically intensive. Services in the second group all concern the care of babies and children, for which specialized personnel and facilities may be required.[19] Emergency services, which are associated with stabilization of patients rather than treatment, appear to stand alone. In conclusion, there appear to be scope economies for two subsets of services that we study.

We prefer the scale and scope explanation of the pattern of thresholds identified in Table 5, rather than the oligopolistic pricing explanation, for two reasons. First, scope economies appear to be present. Second, during the period that we study (1983), a substantial percentage of hospital reimbursements were based on accounting estimates of reasonable costs. This reduces the potential for oligopolistic pricing.

[18] Models of nonprofit organizations frequently predict that the firm seeks efficient production (Jacobs, 1974).

[19] This pattern could also be due to cross-sectional differences in fertility rates. Within California during this period, these variations are minor.

TABLE 6 Cross Correlation Matrix of Prediction Residuals From OLS Estimates of Service Provision Equations

	Cardiology	Deliveries	Diagnostics	Emergency Room	Neonatology	Pediatrics	Teaching	CT Scans	Open-Heart Surgery	Radiation Therapy	Radioisotope Therapy
Cardiology	1.0										
Deliveries	.38	1.0									
Diagnostics	.79	.26	1.0								
Emergency room	.34	.27	.37	1.0							
Neonatology	.49	.65	.36	.25	1.0						
Pediatrics	.56	.67	.57	.20	.54	1.0					
Teaching	.63	.38	.51	.33	.40	.30	1.0				
CT scans	.53	.33	.65	.25	.34	.14	.30	1.0			
Open-heart surgery	.76	.29	.68	.18	.40	.29	.56	.66	1.0		
Radiation therapy	.36	.14	.50	.29	.29	.26	.32	.32	.41	1.0	
Radioisotope therapy	.45	.30	.60	.16	.41	.24	.39	.45	.51	.55	1.0

5. Discussion

■ Heretofore, discussions of the determinants of hospital service provision have focused on the role of quality competition. The empirical analyses associated with these discussions have devoted little attention to a simpler explanation—that the supply of resources is determined by the extent of the market. The empirical specification of the extent of the market has been taken for granted. Our analysis shows that it should not be taken for granted. Local population is a powerful predictor, and any specification that does not carefully consider population is lacking. Also important are measures of fringe supply and demand. When these basic measures of the extent of the market are included in the model, market competition becomes less important.

We cannot completely rule out the MAR hypothesis. The pattern of coefficients suggests that increased competition does lead to a small increase in the supply of specialized services. Given the small magnitude of the identified effect, and the possibility that our results are biased due to inadequate market specification, we think it is difficult to maintain that market competition is an important determinant of resource supply.

Our results augment those of Bresnahan and Reiss (1991), who find that the number of sellers does not increase as fast as local demand does. They interpret this as a competitive effect; i.e., profit margins fall as the number of sellers increases. If we offer this interpretation for our results, then we turn the "inefficient competition" story on its head. That is, competition drives down profit margins, with the result that fewer specialized services are provided. If we instead argue that competitive pricing has no role in determining hospital resource supply, then our results suggest substantial scale economies.

The public policy ramifications of our analysis are substantial. First, our results undermine the importance of the MAR, and they cast doubt on claims that hospital mergers increase efficiency by reducing competition. Second, our results suggest that there may be unexploited scale economies in smaller markets—this may be a superior justification for hospital mergers. The potential for economies in such services as deliveries was an important rationale given for the Roanoke and Augusta mergers. Ironically, the hospitals in a similar merger case in Rockford, Illinois (*USA* v. *Rockford Memorial Corporation and SwedishAmerican Corporation* No. 88 C 20186), did not emphasize scale economies in their premerger analyses or their pretrial briefs. In contrast to the Roanoke and Augusta decisions, the district court judge denied the Rockford merger.

The focus on "inefficient competition" in the recent Roanoke case is troublesome. The presumption that hospital services do not follow the dynamics of supply and demand was too easily accepted by the courts. As we show, one should give great scrutiny to alternatives to traditional market models. The null hypothesis—that the supply of services is determined by the extent of the market—has shown its usefulness for 200 years.

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