Is The Medical Arms Race Still Present In Today's Managed Care Environment?*

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Abstract

Prior to the emergence of managed care, the popular consensus and the majority of research supported the idea that hospitals competed for doctor affiliations and, through them, for patients by offering specialized, high-tech services. This phenomenon was known as the Medical Arms Race (MAR) and was facilitated by the reimbursement practices of health insurance that were common at the time. With the introduction of managed care and the Medicare Prospective Payment System, however, hospitals were no longer able simply to pass on inflated costs to their patients and began to concentrate on reducing costs. This paper examines whether the MAR exists in the current managed care environment. I investigate empirically whether the level of competition in the market influences hospitals in their decision concerning high-tech service provision using a sample of 15 high-tech services across 57 Californian counties. We find that hospitals do take into consideration the level of competition in their markets when deciding whether or not to provide high-tech services, indicating that managed care may not yet have extinguished the MAR.

* I would like to thank Professor Lawrence J. White (Stern School of Business, New York University) for his consistent and insightful guidance in writing this paper. I would also like to thank Professors William Greene, Richard Sylla and Richard Brief for their thoughtful comments and suggestions. This paper is extracted from my Ph.D. dissertation, "Essays in the Economic Behavior of Hospitals", at the Stern School of Business, New York University.

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Summary

Prior to the emergence of managed care, the popular consensus and the majority of research supported the idea that hospitals competed for doctor affiliations and, through them, for patients by offering specialized, high-tech services. This phenomenon was known as the Medical Arms Race (MAR) and was facilitated by the reimbursement practices of health insurance that were common at the time. With the introduction of managed care and the Medicare Prospective Payment System, hospitals were no longer able simply to pass on inflated costs to their patients and began to concentrate on reducing costs. Several authors have shown that the rise of managed care caused hospital costs to fall [1] (See Robinson and Luft 1988, Zwanziger and Melnick 1988, Robinson 1991). However, whether the reduction in hospital costs has occurred due to more efficient operating practices or to a reduction of the specialist services typical of the MAR is unclear.

This paper examines whether the MAR exists in the current managed care environment. We investigate empirically whether the level of competition in the market influences hospitals in their decision concerning high-tech service provision using a sample of 15 high-tech services across 57 Californian counties. The nature of the customers for whom the hospitals are competing has probably changed. Prior to the emergence of managed care, hospitals were competing for doctor affiliations (and through them, patients) whereas, in the current health care environment, hospitals may still be competing for doctors but are probably also competing for managed care provider contracts. However, the underlying idea behind the MAR – that hospitals compete on the basis of service provision – potentially remains the same.

Previous research, with the exception of a paper by Dranove, Shanley and Simon (1992) (DSS), has generally focused on the relationship between hospital costs and competition. This paper focuses on service provision rather than costs. Using a Logistic model, it examines the relationship between the availability of certain high-tech services and the degree of competition in a market. We add to the prior work done using service provision by using more recent data and an improved model. Specifically, we use the proportion of hospital beds rather than number of hospitals as our dependent variable, and we avoid arbitrary grouping of services. We also include a better measure of wage costs and controls for hospital ownership and size that were excluded in the paper by DSS.

We find that hospitals do take into consideration the level of competition in their markets when deciding whether or not to provide high-tech services, indicating that managed care may not yet have extinguished the MAR. Our results contradict those of the DSS paper, which finds that only the extent of the market matters in hospitals' decisions concerning high-tech service provision. This divergence can be attributed to the inclusion of important variables omitted in this previous research that proved significant in our results and, therefore, potentially biases the results of work done without them.

Introduction

Prior to the emergence of managed care in the early 1980s, hospitals competed among themselves for the affiliation of local physicians. The latter had virtually complete discretion over which hospitals they became affiliated with and to which they would direct their patients. It was commonly asserted prior to the emergence of managed care that hospital competition was on the basis of quality and amenities rather than on the basis of price. Competition often took the form of duplication of expensive high-tech medical facilities and service offerings, and this behavior, in turn, led to higher costs of care. This phenomenon was known as the "medical arms race" (MAR), and it proliferated because of the medical insurance environment of the time. Third-party payers with policies of open-ended reimbursement covered most medical expenses, and hospitals were therefore not constrained by price competition.

However, in 1982, the California legislature passed a law enabling third-party payers to negotiate agreements with individual health care providers in which third-party payers would channel patients toward health care providers in exchange for reduced prices. These preferred provider organizations (PPOs) have spread rapidly in California and throughout the United States. With the advent of this and other forms of managed care, hospitals began to change their focus from doctors (and then patients) to managed care insurers (and then patients).

There is significant empirical evidence to support the MAR hypothesis prior to the advent to managed care, and only one paper casts doubt upon it (see Literature Review). Whether or not the MAR persisted *following* the spread of managed care is a relatively open question. Only one study (Zwanziger and Melnick 1988) finds that the link between hospital competition and costs was broken by 1985. However, it is possible that the reduction in costs observed by these authors was due to more efficient operating procedures rather than to a reduction in the number of services and facilities on offer.

The question to be addressed here is whether there is an observable relationship between the level of competition between hospitals and the degree of patient access to high tech services in the current managed care environment. A result in the affirmative could imply that the nature of the MAR essentially remains unchanged from what it was commonly believed to be prior to the advent of managed care: the potential customer may have changed but hospital behavior remains unchanged.

There is, however, an alternative to the MAR that could also explain the positive relationship between competition and provision of services: A monopoly may simply skimp on providing a wider variety or even just skimp on quality if prices are constrained. So, a positive relationship need not imply that competition provides an 'excessive' amount of the high quality service.

Literature Review.

As mentioned above, there has been a significant amount of work done regarding the effects of hospital competition on hospital operating procedures prior to the advent of managed care. Much – but not all -- of the work supports the MAR hypothesis.

We turn first to the cost-based research. Wilson and Jadlow (1982), using the 1973 Census of Nuclear Medicine, examine the relationship between competition and technical efficiency in service provision. Defining competition as a function of hospital density, population density and market size, they find that increased competition is associated with lower technical efficiency.

Farley (1985), using data from 1970 to 1977, finds that hospitals in more competitive counties produced more expensive hospital services by employing more labor and capital per patient. Furthermore, these hospitals perform more procedures for specific diagnoses.

Robinson and Luft (1985), using data from 1972, examine the impact of competition on inpatient admissions, inpatient cost per day and inpatient cost per admission. They find that hospitals in markets with fewer competing hospitals had greater volume and lower costs than those in more competitive markets. Using the same methodology but adding later data, the authors also find similar patterns in 1982 (Robinson and Luft 1987).

Zwanziger and Melnick (1988) examine the introduction of Medicare PPS program in California in 1982 using data from 1980 to 1985. Consistent with the authors already discussed, Zwanziger and Melnick find that, prior to 1982, greater competition led to greater costs. However, for the years following 1982, the authors find that the coefficients on the Herfindahl index, which begins as negative and significant, increase steadily in value until they become insignificant in 1985. In other words, following the introduction of selective contracting, costs fell in areas of high hospital competition until 1985, by which time competition had no bearing on costs. Apparently, at least on the basis of this analysis, the introduction of the Medicare PPS program brought to a halt the medical arms race.

If we turn now to the non-cost based studies, Comstock and Schrager (1979), using 1972 data, find that there was greater overall duplication of services in communities with a higher concentration of physicians. Joskow (1980) examines the effect of hospital competition on bed supply. He finds that hospitals maintain a higher reserve supply of beds in markets with greater competition. Apparently, they do so in order to accommodate the potential needs of their medical staff. Luft et al. (1986), using data from 1972, find that competition among hospitals varies by hospital service but, for most services, hospitals appear to take into consideration the existence and characteristics of the hospitals around them. The authors show that for the majority of services studied, the presence of nearby institutions offering those services increased the likelihood of a neighboring hospital offering the same service.

Dranove, Shanley and Simon (1992) (hereafter 'DSS') challenge the empirical methods used by other researchers. They argue that the MAR "…speaks to the duplication and subsequent underutilization of specific services, yet most of the empirical work focuses on costs".[1] To address this issue, DSS attempt to quantify the provision of services in a market. They identify a few distinctive high-tech services (open-heart surgery, full-body CT scans, radiation therapy, and radioisotope therapy), and group other hospital services along clinical or technological lines. They then categorize hospitals as specialist or non-specialist providers of particular service groups on the basis of the specific features or numbers of services they provide within each service group. The total number of specialist service providers in a market is then used as the dependent variable in the estimation of an ordered probit model that controls for market demand and (roughly) the cost of service provision. DSS then examine whether there is a positive relationship between the number of providers of specialized services and the Herfindahl index.

The second issue raised by DSS concerns the method used to measure of extent of the market. They claim that other authors fail to account for the endogeneity of hospital supply -- larger markets require more hospitals and high-tech services and this leads to higher hospital costs. Consequently, there is a correlation between costs and competition that may not be due to the MAR but rather due to the size of the market. It is, therefore, important to specify correctly the extent of the market. In order to better control for the extent of the market, DSS include not only the community's own demographics but also the population and distance to nearby communities. An endogeneity problem exists in this model because hospitals with more specialized facilities will attract patients and doctors from further away and thus increase the size of the market. However, the authors recognize this problem and claim that, by controlling for potential patient flows, their approach better bounds the resulting bias[2].

The third criticism leveled by DSS at prior research concerns the previous failure to explore scale and scope economies as alternative explanations for the observed differences in costs and specialized service supply across markets. Their use of an ordered probit model enables information to be extracted about competitive behavior and/or scale and scope economies through examination of interval thresholds.

Basing their analysis on 1983 data, and contrary to most of the papers cited above, the authors find only limited support for the Medical Arms Race. They find that the size of the local population and, to a lesser extent, that of the fringe population are key to determining whether a hospital provides a specific service and little else matters. They conclude that, for most markets, the size of the Herfindahl index -- i.e., the degree of competition -- has a negligible effect on service provision in general. However, for 3 of their 11 services (deliveries, diagnostics, and emergency room), a one-standard-deviation rise in concentration would result in 0.5 increase in service provision. The authors dismiss this latter result as insufficient evidence to validate the Medical Arms Race hypothesis.

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[1] DSS (1992) pp. 249.
[2] DSS (1992) pp.248.

There are two problems with the DSS approach. Firstly, the aggregation of services and the definition of specialist service providers are somewhat arbitrary. A redefinition of key services and service groups might lead to different conclusions. Secondly, and more crucially, the MAR question concerns whether hospital competition leads to wasteful duplication of specialized services which DSS (1992, p249) interpret as 'What determines the number of providers of specialized services in local markets?'. However, the *number* of providers is not the key issue from the perspective of wastefulness, but rather the ability of patients to access the treatment provided. Overprovision of a service by the market involves an unnecessary degree of access rather than a greater number of providers. The number of service providers and patient access to the service are not synonymous in this context – the *size* of the hospitals in which the patients are treated is also important, and DSS explicitly omit this. For example, if the service is provided by a few small hospitals (among many) in one county, patients may still have less access to the service than if it was provided by a single large hospital in an otherwise comparable county. However, in this scenario the DSS method would indicate a link between greater service provision and higher competition and might, erroneously, be interpreted as a case of the MAR hypothesis.

Instead of using the total number of facility providers as the dependent variable, a better measure of service provision should involve the relative-size-weighting of those providers. The model used in this paper uses the relative-size-weighted fraction of the hospitals in a market that is be devoted to the high-tech treatment under consideration. The relative size of the hospital is used in the calculation of this variable and it is, therefore, a better representation of service provision to patients – the key concern of the MAR.

Another problem inherent in the DSS paper, and a possible reason that the DSS results contradict previous authors, involves potential misspecification of the model. DSS explicitly exclude variables for case-mix, hospital size, or hospital ownership since they argue that these are endogenous. However, endogeneity alone is not sufficient to exclude potential explanatory variables from a model: doing so may avoid endogeneity bias but will lead to bias due to omitted variables if the excluded variables are significant.

Case-mix and hospital size are endogenous to the extent that it is possible that a hospital's provision of a particular service causes it to attract more patients needing that particular service and the provision of the service itself causes the hospital to be larger than one that does not provide the service. However, it is also true that hospitals in areas with high incidences of particular conditions are more likely to supply specialized facilities to treat them than those with healthier populations. Furthermore, larger hospitals are more likely to provide a larger range of services as part of a complete menu of services. What is required in a model, therefore, is not that hospital size and case-mix are omitted as explanatory variables, but rather that the variables used to measure them do not cause endogeneity bias.

Unlike case-mix and hospital size, it unclear why DSS believe that hospital ownership is endogenous, and they offer no explanation. Ownership, however, may influence the number of specialized services offered by a hospital and a variable is needed to control for it in order to avoid omitted variable bias.

Hypothesis

The hypothesis to be tested is whether hospitals still compete for clients – be they doctors or managed care providers - on the basis of specialized service offerings. I test this hypothesis at the market level by examining the relationship between the proportion of hospital beds with access to specialized services within the same hospital and the level of competition.

Our model differs from previous research in several regards:

- The analysis concerns the provision of services rather than the incidence of cost; most papers concerning the MAR, with the exception of DSS, focus on the incidence of costs.

- I utilize a logistic model, with the dependent variable being the relative-size-weighted fraction of hospitals in a county that offer the specialized treatment under consideration. The size weights are the numbers of beds per hospital, expressed as a fraction of the total hospital beds in a county. Larger hospitals are likely to have more beds and more patients designated to high-tech treatments and, thus, we avoid the problem inherent in the DSS paper whereby simply counting the number of hospitals providing high-tech service may lead to incorrect inferences.

- I avoid the grouping of services and arbitrary definition of service provision 'specialists' inherent in the DSS work. DSS calculate the Herfindahl index based on hospital patient discharges. However, the list of services for which they calculate the Herfindahl includes services that can be provided outside of a hospital environment in stand-alone clinics and doctor's offices. (For example: they include obstetric services in their 'Deliveries' specialist service category). Consequently, the Herfindahl index calculated in the DSS paper understates the degree of competition in the market. Our model includes only those services that can be provided only within hospitals and, thus, avoids this understatement.[3]

- The data used is more recent than that of previous authors (including DSS) – I use 1997 California data that allow for the effects of managed care.

- The explanatory variables include controls for hospital ownership. DSS exclude hospital ownership on the basis of endogeneity. However, while it is possible that hospitals within a market with a higher proportion of non-profit or government hospitals might be less inclined to use service facilities to compete for patients, it is difficult to see how hospital ownership might be endogenous, and DSS offer no explanation.

[3] Ideally, the Herfindahl index would include only those patients who are actually treated with the high-tech service in question. However, data are not available at this level of granularity.

- A proxy for hospital size is included as an explanatory variable. DSS' endogeneity concerns are valid: where hospitals provide particular high-tech services, they are likely to be larger. However, hospital size should be included as an explanatory variable since larger hospitals are likely to offer a wider range of facilities. To avoid the problem of endogeneity, I use the number of management hours as an instrument for hospital size. Unlike other potential measures of size such as the number of beds and number of admissions, this variable is less directly related to whether or not high-tech services are provided and, therefore, reduces or avoids the potential endogeneity problem.

- I include measures of population age and income to control roughly for case-mix.

- The model includes a more comprehensive measure of labor costs. DSS use the wages of aides and orderlies across hospitals to account for labor costs, and their measure has the benefit of not reflecting hospital quality or service provision. Although exogenous, the wages of aides and orderlies are potentially too narrow as a measure or hospital labor costs reflecting as they do only the supply and demand of aides and orderlies (relatively unskilled labor). In contrast, hospital labor costs comprise a wider range of workers requiring a broader measure of hospital wage cost to include more skilled employees.

  I construct a wage index at the county level based on seven different categories of hospital worker. By basing the index on the employee composition of the *average* hospital in the state, I avoid the issues of endogeneity that arise if hospitals with more high-tech equipment have higher proportions of more highly skilled staff.

  As a further control for costs, I also include a measure of retail wages across counties. This serves as a measure of background cost that may not be reflected by the hospital labor cost measure.

Model

The model examines hospital service provision at the market level, and we define hospital markets to be delineated along county lines. Specifically, we examine the relative-size-weighted fraction of hospitals in a county that offer specific high-tech services. A logistic model based on grouped (proportion) data is used for the analysis.

In our model:

P_i is the observed proportion of beds in the county i providing access to particular high-tech service,
$\mathbf{x_i}$ are independent supply and demand variables in county i, and
n_i is the number of beds in the county.

The model is built around the logistic function:

$$\pi_i = \frac{\exp(\beta' x_i)}{1+\exp(\beta' x_i)}$$

where π_{ij} is the population proportion of beds in county i having the same $\mathbf{x_i}$

We assume that p_i is an estimate of the population quantity; thus:

$$p_i = \pi_i + \varepsilon_i = \frac{\exp(\beta' x_i)}{1+\exp(\beta' x_i)} + \varepsilon_i \qquad \text{......(1)}$$

Furthermore,

$$E[\varepsilon_i] = 0, \quad Var[\varepsilon_i] = \frac{\pi_i(1-\pi_i)}{n_i}$$

Since the model is heteroscedastic, we weight each observation by:

$$w_i = (herf_i)^{-1/2}$$

where $herf_i$ is the Herfindahl index for county i.

This approach gives greater weight to the observations of those counties in which there is greater competition and less to those in which market power is more concentrated.

Our weighting variable is carefully chosen. Firstly, we rule out the use of the number of beds in the market because the decision regarding whether or not to provide a service is made at the hospital level, not at the bed level. We also choose not to weight simply by the number of hospitals in a county because the variance of the errors is likely to differ with market concentration. Suppose a market contains a single dominant hospital and several other smaller hospitals: the variance of the errors is likely to be higher in this market than in one in which the same number of hospitals exists but where the hospitals are all similar in size. A weighting based solely on the number of hospitals would miss this important distinction.

The Herfindahl index has distinct advantages of its own. Not only does it take into consideration the size composition of hospitals in the market, but it also has the property that its inverse is a ‘numbers equivalent’ measure of market concentration. For example, suppose that a market consists of 5 hospitals with the following market shares: 0.5, 0.2, 0.1, 0.1, 0.1. The Herfindahl index would be 0.32. The inverse of 0.32 is approximately 3; and a market composed of 3 equal size firms would also yield a Herfindahl of 0.33. (Similarly, if a given market structure yielded a Herfindahl of 0.2, the inverse of 0.2 is 5; and a market composed of 5 equal size firms would also yield a Herfindahl of 0.20). Thus, weighting by the Herfindahl index is equivalent to weighting by a rough-equivalence measure of the number of hospitals in the market, with the added benefit that patterns of market concentration and their associated different variances are taken into consideration.

The model is estimated using Maximum Likelihood methods and the log likelihood function for this model is:

$$LnL = \sum_{i=1}^{n} n_i [p_i \ln \frac{\exp(\beta' x_i)}{1+\exp(\beta' x_i)} + (1-p_i)\ln(1-\frac{\exp(\beta' x_i)}{1+\exp(\beta' x_i)})] .$$

The marginal effects are correspondingly:

$$\frac{\delta E[p_i \mid x_i]}{\delta x_i} = \frac{\exp(\beta' x_i)}{(1+\exp(\beta' x_i))^2}\beta_i \qquad \ldots(2)$$

Variables

In our application, the variables in **X** consist of service-specific dummy variables, variables to measure the extent of the market, ownership variables to reflect the proportion of beds in the different ownership categories (non-profit / government / for-profit hospitals), variables to measure the cost of doing business, a measure of hospital size in the market, and, most importantly, the degree of competition in the market. Again, the observations are per market – i.e., per county.

Dependent Variable

We define our market as the county in which the hospital is located. As discussed in the 'Hypothesis' section above, the dependent variable p_i, is defined as the relative-size-weighted fraction of the hospitals in a county that offer a particular high-tech service. (Dummy variables are used to indicate the specific high-tech service in question). We first determined whether a hospital provided the high-tech service in question and how many beds there were within it. Then, the total number of beds at all such hospitals in the county was calculated, and the result divided by the total number of hospital beds in the county, providing us with the dependent variable.

The services we examine are listed in the OSHPD[4] Services Inventory as: “Burn Intensive Care”, “Coronary Intensive Care”, “Medical Intensive Care”, “Neonatal Intensive Care”, “Neurosurgical Intensive Care”, “Pediatric Intensive Care”, “Pulmonary Intensive Care”, “Surgical Intensive Care”, “Cobalt Therapy”, “Diagnostic Radioisotope”, “Nuclear Medicine”, “Radiation Therapy”, “Radium Therapy”, “Radioactive Implants”, and “X-ray Radiology Therapy”. These specific services were selected for examination in this paper since they are high-tech and expensive to provide – precisely the kind of services that the MAR was reputed to affect. Unlike DSS, we do not aggregate services into specialist groups since this necessitates an element of subjectivity that we wish to avoid. Furthermore, these services are provided exclusively on a hospital inpatient basis – they cannot be provided at doctors’ offices or by specialist service providers (as in the case of MRI services, for example). The advantage of including these services in the sample is, therefore, that we can accurately define the number of competitors in a county and subsequently calculate the Herfindahl index.

Independent Variables

In order to estimate the effect of market concentration on service provision, we control for market demand, the cost of service provision, hospital ownership, and hospital size, all of which to affect a hospital’s decision to offer specialized services. The independent variables are as follows:

There are 14 dummy variables indicating the specific service to which the dependent applies. These dummy variables are coded ‘1’ for the service in question, and ‘0’ otherwise. The services to which the dummy variables refer are as follows:

- CORON Coronary Intensive Care
- MED Medical Intensive Care
- NEONAT Neonatal Intensive Care
- NEURO Neurosurgical Intensive Care
- PED Pediatric Intensive Care
- PULMNRY Pulmonary Intensive Care
- SURG Surgical Intensive Care
- COBALT Cobalt Therapy
- ISOTOPE Diagnostic Radioisotope
- NUCLEAR Nuclear Medicine
- RADIAT Radiation Therapy
- RADIUM Radium Therapy
- IMPLANTS Radioactive Implants

[4] OSHPD is the Office Of Statewide Health Planning and Development in California.

- RADIO Radiology Therapy

The 15th category – the default category – is that of "Burn Intensive Care".

- HERF The Herfindahl index[5] is calculated using annualized patient discharges. Where hospitals are under common ownership, they are treated as a common firm for purposes of calculating the Herfindahl index.

- HOSP_SIZ The average number of management hours (÷ 10,000) in the county.[6]

- W_WG_IND A county-wide weighted index of hospital wages. There are 7 types of employee namely, There are 7 types of employee namely,

  k=1: Managerial and Supervisory Employees (typical job titles of employees included in this category are Administrators, Directors, Managers, and Supervisors),

  k=2: Technical and Specialist Employees (employees in this category generally perform activities of a creative or complex nature, and are often licensed or registered e.g.: Technologist, Technician or Accountant),

  k=3: Registered Nurses (includes only registered nurses involved in the direct nursing care of patients – not those employed in roles as supervisors or instructors),

  k = 4: Licensed Vocational Nurses (includes only those licensed vocational nurses involved in the direct nursing care of patients),

  k = 5: Aides and Orderlies (includes non-technical personnel employed in the direct nursing care of patients),

  k = 6: Environmental and Food Service Employees (includes Housekeeping Aide, Cook's Helper, Guard, and Maintenance Person).

  k = 7 Clerical and Other Employees (The largest part of this category relates to non-technical personnel employed in record keeping, communication, and other administrative type functions).

  The proportion of hours worked by each type of employee was calculated at the statewide level. This provided a pattern of 'standardized' hospital employment – irrespective of the type of services offered. These proportions were then multiplied by the individual wage rates for each type of employee at each hospital to give a standardized wage index for each hospital. In turn,

[5] Defined as Σs_{hj}^2 where s_{hj} is the share of hospital h of the total cases treated in the county j.
[6] The "natural" measure of hospital size would be the number of beds, or admissions. However, these variables are potentially endogenous - hospitals with specialty units are likely to have more beds and more admissions.

these indices were then weighted by the hospital's proportion of the total number of management hours in the county in order to arrive at a county level variable.

The number of management hours was chosen as a weighting variable in order to avoid the endogeneity bias that may arise from weighting by either the number of hospital beds, total admissions, or total hours worked. These latter variables are directly related to the size of the hospital and this in turn may be at least partially explained by whether high-tech services are provided – thus weighting a wage index by one of these variables could cause endogeneity bias. Management hours, on the other hand, are less likely to be as directly correlated with hospital size.

- RETAIL_W — County Average Retail Wage Payment ($000), Q1 1996.[7] This variable is used as an indication of the general wage (cost) level in the hospital's county.

- PR_GOVT — The proportion of total hospital beds in the county that are located in hospitals classified by OSHPD as being Government or District owned hospital.

- PR_NFP — The proportion of total hospital beds in the county that are located in hospitals classified by OSHPD as being operated by a church, non-profit corporation, or other form of non-profit operation.

- PR_THIRD — The proportion of patients in a county whose treatment is expected to be paid for by third party payers. This type of payer includes private, non-profit, or commercial health plans, whether insurance or other coverage.[8] This variable is included because hospitals have more control over the prices they receive from these types of payers than they do over those charged to Medicare and Medicaid payers; consequently, they may be able to pass on increases in their costs associated with high-tech services more easily to these payer types.

- PR_TEACH — The proportion of total hospital beds in the county that are located in hospitals classified by OSHPD as being teaching hospitals.[9] Counties with high proportions of teaching hospital beds are expected to provide either more than or the same access to high-tech services that counties with lesser proportions of teaching beds.

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[7] From County Business Patterns 1996 published by the U.S. Census Bureau, in *the Official Statistics*, Nov 23, 1998

[8] Included are payments by local or organized charities, such as the Cerebral Palsy Foundation, Easter Seals, March of Dimes or Shriners.

[9] Classified by OSHPD as 'teaching' in the Hospital Annual Financial Data – Selected Data File 1999.

- POPN	Local Population. Measured in 10,000's of people, this is the total number of people in the county.

- POP_DEN	Population Density within the county (100 people per square km) in 1996[10].

POP_DEN and POPN are included as a measure of the local market demand. Both variables are obtained from the 1990 census.

- OVER_60	The proportion of the population in the county who are aged sixty and above.

- UNDER_16	The proportion of the population in the county who are aged 16 and below.

- PER_CAP	Per Capita Income by County in 1996 ($10,000)[11].

OVER_60, UNDER_16 and PER_CAP are included as a rough control for case-mix. PER_CAP also measures the population's ability to pay for a service, and therefore, is part of the measure of local market demand.

Summary Statistics for all the above variables appear in **Appendix A**.

Data

The data encompass 15 high-tech service categories offered that may be offered within 57 counties in California[12], yielding a total of 855 observations.

Most of the patient and hospital level data were obtained from the Office of Statewide Health Planning and Development (OSHPD) in California. OSHPD's Hospital Financial Data 22nd Year (6/30/96 – 6/29/97) supplied the service provision data, and its Hospital Annual Financial Data Profile (HAFD1297) provided the number of licensed beds at each hospital; these two datasets were used together to construct the independent variable. The Hospital Annual Financial Data Profile was also used to provide the type of hospital ownership (for-profit, non-profit or government), whether it was a teaching hospital, and the total number of third party patients discharged from each hospital. It also provided the total number of patients discharged from each hospital during the year and the name of the hospitals' owners from which the Herfindahl index was constructed.

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[10] From the 1998 County and City Extra, Annual Metro, City and County Data Book.
[11] From Survey of Current Business, May 1998, U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis
[12] There are no hospitals in the 58th county - Alpine County.

County-specific data were obtained from a variety of sources: Age distribution data and total population data were obtained from the US Census Bureau, 1990 Decennial Census[13], per capita income data were obtained from the Survey of Current Business, May 1998[14], county retail wage data were obtained from County Business Patterns 1996 published by the U.S. Census Bureau, in *the Official Statistics*, Nov 23, 1998, and population density data for 1998 were obtained from the 1998 County and City Extra: Annual Metro, City and County Data Book.

OSHPD's Individual Hospital Financial Data[15] provided the average hourly wages of 7 types of employee, the total hours worked at the hospital, and the proportion of the total hours worked by each category of employee. These data were used to construct the W_WG_IND variable and the MAN_HRS variable described in the dependent variable section above.

Results

The results of the logistic estimation appear in **Appendix B**. The estimates presented in **Appendix B(1)** are the maximum likelihood estimates of expression (1) in the Model section above, while **Appendix B(2)** provides the partial derivatives of the probabilities with respect to the independent variables (per expression (2) in the Model section above) that are computed at the means of the independent variables.

The model fits the data well. The chi-squared statistic for testing the joint significance of all the coefficients in the model was 1,181.57 compared to a critical value of $\chi^2(27) = 49.65$, indicating a highly significant overall regression.

The main result of this analysis is that, controlling for market size, the MAR theory is supported. The coefficient on the partial derivative associated with the Herfindahl index is negative and highly significant when evaluated at the mean of the explanatory variables, thus indicating that a decrease in the Herfindahl of 0.1 leads to an increase of 0.026 in the probability that high tech services are supplied. In other words, hospitals are more likely to supply a high tech service when they are located in more competitive markets, controlling for other influences.

Total population in the county also influences whether hospitals provide high-tech services – an additional 100,000 people leads to a 1.4% decrease in the probability that a high tech service is provided. Population density is insignificant at the 95% level but is significant at the 90% and is also negative. At first glance the signs on these variables appear counterintuitive, and contradict the findings of DSS, who find that the population of the local market and that of the surrounding markets are significant. However, these results can potentially be explained by our market definition. Our

[13] Age distribution data were obtained from: Table PO11-AGE, Universe: Persons, Dataset: 1990 Summary Tape File 1 (STF1).
[14] Published by the U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis
[15] Individual Hospital Financial Data for California 1996-97, California Office of Statewide Health Planning and Development.

market definition is much broader than that of DSS. Our sample includes all counties in California in which there is a hospital, whereas DSS define their markets as urbanized areas with population densities exceeding 1,000 per square mile or cities with populations greater than 5,000 in non-urbanized areas. Consequently, some of our markets have populations and population densities that are so low that the usage levels of the high-tech equipment are probably not justified. However, since the alternative is for all patients in the county to be unable to access medically necessary procedures, hospitals choose to supply these services despite the economic inefficiency associated with so doing.

Another explanation for the difference in sign on the population variable in our model compared to that of DSS involves DSS' exclusion of important explanatory variables. Our model reveals that hospital size is a significant determinant of whether hospitals provide high-tech services – an increase in hospital size requiring approximately 5 more managerial staff per hospital in a county (or 10,000 managerial staff hours) would increase the probability of high-tech service provision by nearly 1.6%. As discussed previously, DSS exclude hospital size on the basis of its endogeneity; however, as expected, this is an important variable, and its omission probably causes the DSS results to be biased.

The other variables excluded by DSS but included in this model concern hospital ownership. It appears from these results that there is no difference between the decision-making processes of non-profit hospitals and their for-profit counterparts. Government hospitals, on the other hand, are less likely to provide high-tech services and, once again, failure to account for this difference in ownership may have contributed to bias in the DSS results.

We turn now to the other important variables in the model. As expected, the teaching status of a hospital has an important positive influence over whether a high tech service is provided. A county in which the proportion of teaching beds is 10% higher than an otherwise comparable county, would have a 4% greater probability of high tech services being provided. Also, a county in which hospitals are larger is more likely to have high tech service providers.

Conclusions

We set out to investigate whether the MAR still exists despite the advent of managed care, and our results indicate that hospitals take into consideration the level of competition in their markets when deciding whether or not to provide high-tech services. Supporters of the MAR theory generally explain higher levels of service provision in more competitive markets as evidence of the MAR and would argue that these results indicate that indeed the MAR exists in the current managed care environment.

Our results also support an alternative argument that monopolists may skimp on service provision and possibly also service quality when they are price constrained by managed care providers. Donnenfeld and White (1990) assume that the monopolist produces two types of service – high and low quality – and that there are two types of consumer (high willingness to pay and low willingness to pay). If the absolute and marginal willingness to pay of the two consumer groups are negatively correlated, the monopolist has an incentive to distort the quality of his high quality service. In the extreme case, this may lead to monopolists producing only the low quality product. Consequently, our results may not indicate the "over provision" of high-tech services when there are high levels of competition but rather the "under provision" of services when markets are highly concentrated.

Appendix A

Descriptive Statistics
All results based on nonmissing observations.

Variable	Mean	Std.Dev.	Minimum	Maximum	Cases
All observations in current sample					
PR_C_BD	.456931904	.406470056	.000000000	1.00000000	855
CORON	.666666667E-01	.249589827	.000000000	1.00000000	855
MED	.666666667E-01	.249589827	.000000000	1.00000000	855
NEONAT	.666666667E-01	.249589827	.000000000	1.00000000	855
NEURO	.666666667E-01	.249589827	.000000000	1.00000000	855
PED	.666666667E-01	.249589827	.000000000	1.00000000	855
PULMNRY	.666666667E-01	.249589827	.000000000	1.00000000	855
SURG	.666666667E-01	.249589827	.000000000	1.00000000	855
COBALT	.666666667E-01	.249589827	.000000000	1.00000000	855
ISOTOPE	.666666667E-01	.249589827	.000000000	1.00000000	855
NUCLEAR	.666666667E-01	.249589827	.000000000	1.00000000	855
RADIAT	.666666667E-01	.249589827	.000000000	1.00000000	855
RADIUM	.666666667E-01	.249589827	.000000000	1.00000000	855
IMPLANTS	.666666667E-01	.249589827	.000000000	1.00000000	855
RADIO	.666666667E-01	.249589827	.000000000	1.00000000	855
PER_CAP	2.20628596	.645989551	1.43940000	4.53050000	855
POP_DEN	.230754386	.811615361	.100000000E-02	6.03200000	855
POPN	5.22112298	12.4005470	.331800000E-01	88.6000000	855
OVER_60	.170736842	.420782670E-01	.990000000E-01	.289000000	855
UNDER_16	.251473684	.354603905E-01	.152000000	.325000000	855
HERF	.532589474	.315157550	.448000000E-01	1.00000000	855
W_WG_IND	17.5818740	2.63378684	12.8405850	24.3483565	855
RETAIL_W	3.39191807	.502577452	2.49517000	4.70834000	855
PR_GOVT	.271191228	.355019393	.000000000	1.00000000	855
PR_NFP	.633721053	.361251501	.000000000	1.00000000	855
HOSP_SIZ	7.64287104	4.45151513	.869709000	23.2435000	855
PR_THIRD	.336296491	.132030900	.631000000E-01	.723600000	855
PR_TEACH	.569087719E-01	.132509707	.000000000	.734800000	855

APPENDIX B(1)

```
+--------------------------------------------+
| Multinomial Logit Model                    |
| Maximum Likelihood Estimates               |
| Dependent variable              PR_C_BD    |
| Weighting variable             INV_HERF    |
| Number of observations              855    |
| Iterations completed                 39    |
| Log likelihood function       -1292.897    |
+--------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
	Characteristics in numerator of Prob[Y = 1]				
Constant	-6.496894998	1.5866647	-4.095	.0000	
CORON	4.811974392	.37090875	12.973	.0000	.66666667E-01
MED	5.703994160	.41652118	13.694	.0000	.66666667E-01
NEONAT	2.746615051	.33645312	8.163	.0000	.66666667E-01
NEURO	2.852006884	.33664668	8.472	.0000	.66666667E-01
PED	2.635976405	.33640896	7.836	.0000	.66666667E-01
PULMNRY	3.975640501	.34818050	11.418	.0000	.66666667E-01
SURG	5.511576593	.40422335	13.635	.0000	.66666667E-01
COBALT	1.206979756	.35361812	3.413	.0006	.66666667E-01
ISOTOPE	4.214005654	.35317132	11.932	.0000	.66666667E-01
NUCLEAR	4.982550072	.37760203	13.195	.0000	.66666667E-01
RADIAT	2.384169806	.33693253	7.076	.0000	.66666667E-01
RADIUM	2.336596082	.33713225	6.931	.0000	.66666667E-01
IMPLANTS	2.183698913	.33800216	6.461	.0000	.66666667E-01
RADIO	2.845745366	.33663108	8.454	.0000	.66666667E-01
PER_CAP	.2529524978	.20569354	1.230	.2188	2.3679900
POP_DEN	-.1662017999	.93481588E-01	-1.778	.0754	.47903749
POPN	-.5825950742E-02	.26359376E-02	-2.210	.0271	17.314361
OVER_60	-2.679807481	2.6334846	-1.018	.3089	.15669596
UNDER_16	5.367291074	3.2304333	1.661	.0966	.25022111
HERF	-1.049063535	.32280290	-3.250	.0012	.31199200
W_WG_IND	.4116770555E-01	.43304827E-01	.951	.3418	18.143374
RETAIL_W	.4708119955	.22316567	2.110	.0349	3.6508056
PR_GOVT	-1.273143676	.39324860	-3.238	.0012	.21725297
PR_NFP	-.4831089454E-01	.35150715	-.137	.8907	.61128796
HOSP_SIZ	.6591057180E-01	.25883831E-01	2.546	.0109	10.125027
PR_THIRD	-1.175894678	.74274266	-1.583	.1134	.37916429
PR_TEACH	1.715520014	.57203678	2.999	.0027	.11529249

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

APPENDIX B(2)

Partial derivatives of probabilities with respect to the vector of characteristics. They are computed at the means of the Xs.

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
	Characteristics in numerator of Prob[Y = 1]				
Constant	-1.582734269	.38760750	-4.083	.0000	
	Marginal effect for dummy variable is P|1 - P|0.				
CORON	.4915424962	.16495418E-01	29.799	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
MED	.5109400440	.15508741E-01	32.945	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
NEONAT	.4123754608	.25705026E-01	16.043	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
NEURO	.4188370360	.24640710E-01	16.998	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
PED	.4051263137	.26942977E-01	15.036	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
PULMNRY	.4682485046	.18220051E-01	25.700	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
SURG	.5070459109	.15695919E-01	32.304	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
COBALT	.2496395354	.57631093E-01	4.332	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
ISOTOPE	.4756433608	.17582883E-01	27.051	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
NUCLEAR	.4955625155	.16271050E-01	30.457	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
RADIAT	.3866379538	.30272230E-01	12.772	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
RADIUM	.3828041221	.30987928E-01	12.353	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
IMPLANTS	.3696739271	.33490097E-01	11.038	.0000	.66666667E-01
	Marginal effect for dummy variable is P|1 - P|0.				
RADIO	.4184646310	.24700965E-01	16.941	.0000	.66666667E-01
PER_CAP	.6162275775E-01	.50105815E-01	1.230	.2188	2.3679900
POP_DEN	-.4048907737E-01	.22767411E-01	-1.778	.0753	.47903749
POPN	-.1419282887E-02	.64219190E-03	-2.210	.0271	17.314361
OVER_60	-.6528384920	.64154914	-1.018	.3089	.15669596
UNDER_16	1.307546992	.78707425	1.661	.0967	.25022111
HERF	-.2555665140	.78701630E-01	-3.247	.0012	.31199200
W_WG_IND	.1002902746E-01	.10550822E-01	.951	.3418	18.143374
RETAIL_W	.1146963711	.54372810E-01	2.109	.0349	3.6508056
PR_GOVT	-.3101555629	.95831379E-01	-3.236	.0012	.21725297
PR_NFP	-.1176920796E-01	.85630934E-01	-.137	.8907	.61128796
HOSP_SIZ	.1605673490E-01	.63029555E-02	2.547	.0109	10.125027
PR_THIRD	-.2864643501	.18096050	-1.583	.1134	.37916429
PR_TEACH	.4179246110	.13928740	3.000	.0027	.11529249

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

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