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The Effects of Competition and
Regulation on Hospital Bed Supply and the
Reservation Quality of the Hospital

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Introduction

Discussions of hospital behavior and performance in the U.S. have been dominated by consideration of the supply of hospital beds and associated hospital occupancy rates. An important component of a leading model of hospital costs and utilization is an exogenous hospital target occupancy rate.¹ Policy discussions of hospital costs and hospital cost inflation have focused on what is perceived to be a costly "excess bed" problem in the U.S. hospital sector.² An incredibly complex system of state and federal planning and regulatory agencies is largely predicated on the assumption that an uncontrolled hospital sector will supply far more beds than are required to serve the demands for hospital care efficiently.

This paper explores the characteristics of the hospital's bed supply planning problem in the context of a simple queuing model that has attracted considerable attention in the operations research literature and by hospital planners. This model is utilized to estimate the bed supply decisions and reservation quality of U.S. hospitals based on a sample of 346 non-profit community hospitals. The effects on bed supply of quality competition among hospitals, certificate-of-need regulation and prospective reimbursement are also investigated empirically.

The paper proceeds in the following way. Section 1 presents a simple queuing model of hospital admissions and bed supply decisions which reflects particular assumptions about the stochastic characteristics of hospital demand. This model yields a fairly simple relationship between bed supply and

expected demand and a parameter which is a measure of the reservation quality of the hospital. Estimates of this model are then presented based on a random sample of non-profit hospitals in the U.S. in 1976. Section 2 discusses the impact of non-price competition among hospitals on bed supply decisions and the role of state certificate-of-need regulation and rate regulation on these decisions. The model presented in Section 1 is then respecified to include variables to measure the intensity of non-price competition and state regulation and additional estimates based on this expanded model are developed. Section 3 explores the nature of hospital utilization further. This discussion suggests that the simple queuing model that was specified previously and that has attracted considerable public policy attention does not account for several important characteristics of hospital demand and the internal organization of hospitals. An effort is made to examine the qualitative importance of two of these characteristics and it is shown that the "naive" queuing model probably overestimates the reservation quality of a hospital, given the data that are typically available. Section 4 discusses the empirical results and provides some suggestions for further work. Analyses of hospital behavior and performance necessarily raise many difficult and complex issues. I have made an effort to explore some of these in footnotes, which I strongly suggest be read along with the text.

A Simple Queuing Model of Hospital Capacity Decisions

The demand for hospital services is stochastic, varying from day to day and from month to month. As a result, a hospital that attempts to meet peak demands may be operating at full capacity during a few days of the year, turning some patients away or increasing admission delays during these periods. During most days of the year, however, the hospital will not be operating at full capacity, in the sense that the daily census is below the licensed number of beds that a hospital has. This means that the average annual occupancy rate of a hospital is likely to be significantly below 100% even if it is operating at full capacity during several days of the year. In 1977 the average annual occupancy rate for community hospitals in the U.S. was 74% and this value tends to vary directly with the size of the hospital.³

A key issue in determining the "optimal" amount of hospital capacity for a particular hospital or health service area is the determination of the appropriate probability that a hospital will be full and patients turned away or queued up. The appropriate value for this turnaway probability depends on the kinds of patients served by the hospital (emergency vs. elective), the distance to other hospitals and availability of services in other hospitals that patients may be forced to turn to, the admissions or queuing discipline used by the hospital, the value that patients put on rapid admission, and the costs of maintaining various levels of hospital capacity.

The operations research literature includes a number of efforts to apply a variety of queuing models to the capacity planning problem of hospitals. In this section, I will briefly present a particular birth and death queuing model for hospital utilization that has attracted a great deal of attention in the hospital planning literature and has been utilized by some state planning agencies.⁴ The model is sketched out briefly here and

is an adaptation of the Poisson Input Servers, Blocked Customers cleared model presented by Cooper.⁵

All queuing models require that the following aspects of patient demand and hospital (server) behavior be specified.

(a) The input process specifies the stochastic characteristics of patient arrival patterns;

(b) The service mechanism specifies the available supply of beds and the distribution of patient lengths of stay;

(c) The queue discipline specifies how patients are treated on arrival when the hospital is at various levels of utilization.

The simple queuing model that has been used extensively in the hospital planning literature has the following specifications of patient demand and hospital behavior.

The input process assumes that patients arrive at the hospital according to a Poisson (or random) process with a mean arrival rate of L patients per day. The service mechanism assumes that there are s beds and that the utilization time (length of stay) is distributed negative exponentially with the mean length of stay given by $1/u$.⁶ The queue discipline assumes that patients who arrive either find an empty bed and are admitted or if the hospital is full they are turned away and leave the system.

Let $N(t)$ be a random variable with realizations $0, 1, 2, \dots$ representing the number of patients in the hospital at time t . We say that the system is in state E_j at time t if $N(t)=j$. The statistical equilibrium probabilities that j beds are full ($N(t)=j$) is given by

$$(1) P_j = \frac{(L/u)^j / j!}{\sum_{k=0}^s (L/u)^k / k!} \quad j=0,1,\dots,s$$

$$(2) P_j = 0 \quad j > s$$

which is called a truncated Poisson distribution. If s is infinite we get

$$(3) P_j = \frac{(L/u)^j}{j!} e^{(-L/u)} \quad j = (0,1,\dots)$$

which is a Poisson distribution with mean (L/u) . That is, in the infinite bed model the distribution of $N(t)$ is Poisson with mean (L/u) . Generally, as s gets large relative to (L/u) the Poisson distribution with mean (L/u) becomes a good approximation for the birth-death queuing model's probabilities described by this simple model.

As a general matter, we don't observe L directly since "arrivals" and "admissions" will not be the same; we observe only admissions. However, if patients are rarely turned away, as appears to be the case in most hospitals, then we can use the Poisson distribution with a mean equal to the average daily census (ADC) as an approximation to the system.⁷

The Poisson distribution has two convenient characteristics:

(a) the standard deviation is the square root of the mean

(b) with the mean of the distribution reasonably large the normal distribution with the same mean is a good approximation to the Poisson distribution (although remember that one is continuous and one is discrete). Therefore, we can select the probability of the hospital being full at any level we want by choosing how many standard deviations k from the mean (ADC) we want the number of available beds (BEDS) to be:⁸

$$(4) \text{ BEDS-ADC} = k\sqrt{\text{ADC}}$$

We can think of BEDS-ADC as representing the average reserve margin R for the hospital

$$(5) R = k\sqrt{\text{ADC}}$$

The greater is k (the number of standard deviations from the mean daily census), the larger is the average reserve margin of the hospital and the smaller is the probability that the hospital will be full and patients turned away. Therefore k is a measure of the reservation quality of the system.

Obtaining an accurate estimate of the value of k in (5) may be useful for making welfare judgments about the prevailing levels of bed capacity in the U.S. hospital system. As a general matter, as the value of k increases, adding an additional bed to the hospital results in a smaller number of patients not turned away who otherwise would have been. In other words, the marginal cost of turning away fewer patients increases as the value of k increases. To give some empirical content to this statement, table 1 presents values for the marginal cost per additional patient that is not turned away using this model. In 1976 the average inpatient expenditures per bed in community hospitals was about \$41,000 per year. The estimates presented in table 1 are based on the assumption that the cost of an additional unit of hospital capacity is equal to 50% of the average total cost per bed. This appears to be a reasonable upper bound estimate for the marginal cost of capacity given the existing econometric evidence.⁹

Table 1

<u>k</u>	<u>Marginal Cost per Additional Patient Admitted</u> ¹⁰
4.0	\$2,000,000
3.5	240,000
3.0	43,000
2.5	9,000
2.0	2,000

At high values of k , increasing capacity has only a trivial effect on the number of patients turned away each year and as a result the marginal cost per additional admission is quite high. As a value of k declines, incremental changes in hospital capacity have more significant effects on the turnaway probability and the marginal cost declines rapidly. The "optimal" value of k depends on a comparison of these (or alternative) marginal cost estimates and the value to the marginal patient of being admitted rather than turned away.

This simple queuing model also has potentially interesting implications for the relationship between the magnitude of the demand on the hospital and the average occupancy rate of the hospital for a given value of k . As the expected daily demand (ADC) on the hospital increases, the average occupancy rate of the hospital also increases for any given value of k . This means that as the demand for hospital services increases for a particular hospital the average cost of maintaining a particular level of reservation quality falls. The stochastic nature of demand may therefore be an important source of scale economies.¹¹ For example, with k set at 2.5 standard deviations we would get the following distribution of ADC, BEDS, and average occupancy rates from this model.

<u>ADC</u>	<u>BEDS</u>	<u>Average Occupancy Rate</u>
10	18	56%
25	37	68%
100	125	80%

This relationship has direct implications for regulatory efforts that attempt to constrain perceived excessive hospital capacity by setting uniform target average occupancy rate criteria for all hospitals.¹² If we want to maintain equivalent reservation qualities across hospitals we don't want to apply the same occupancy rate criterion to small rural hospitals as we apply to larger urban hospitals. To maintain equal reservation qualities the target occupancy rates should vary directly with the average daily census of the hospital. Using a uniform criterion disadvantages small hospitals relative to large hospitals if they are in competition with one another. To the extent that smaller hospitals are located in rural areas¹³ a uniform criterion also favors urban patients relative to rural patients, both because reservation quality would be lower in the small rural hospitals and because greater distances between hospitals increases the costs of being turned away.

Let us now turn to the problem of estimated k in (5). The requisite data for 346 random non-profit community hospitals have been drawn from the 1976 American Hospital Association (AHA) Annual Survey. We assume that the stochastic structure of (5) implies an additive error term and that ordinary least squares gives consistent estimates of k . Equation (5) is estimated

using ordinary least squares for the entire sample as well as separately for the smaller hospital (hospitals with ADC below the median) in the sample and for the larger hospitals (hospitals with ADC above the median). Standard errors are reported in parentheses below the coefficient estimates.

- | | | |
|-----|--|----------------------------------|
| (1) | $R = +3.85\sqrt{\text{ADC}}$
(0.11) | 346 observations |
| (2) | $R = +4.02\sqrt{\text{ADC}}$
(0.18) | hospitals with ADC < median |
| (3) | $R = +3.82\sqrt{\text{ADC}}$
(0.15) | hospitals with ADC \geq median |

The estimated value of k is about 4 standard deviations. There is no significant difference in the estimated value of k between the smallest hospitals in the sample and the largest hospitals. In all cases k is estimated quite precisely.¹⁴ A value of k of this magnitude implies that the probability of being turned away is less than one in ten thousand. For a hospital with an average daily census of 200 (about 255 beds) and an average length of stay of 7.5 days this implies that less than one patient per year would be turned away. If this is a reasonably accurate model of patient demand and hospital behavior, the estimated turnaway probability is very low indeed. As we discuss further below, after including the effects of inter-hospital competition and regulation, there are good reasons to believe that using this model with the data that are typically available tends to overestimate seriously the actual reservation quality of the hospital, however.

Non-Price Competition and Regulation

A. Competitive Factors

The previous discussion treats the hospital as an organization that responds in a particular way to the stochastic demands for inpatient services that it faces. Rather than choosing a target occupancy rate directly, the hospital chooses a target reservation quality, defined by k , which in turn implies a target occupancy rate that varies with the average daily census of the hospital. The behavior of other hospitals in the area is generally ignored. The examination of the behavior of a single hospital in isolation from its environment is typical of the theoretical literature on hospital behavior. Generally, the hospital is viewed as a monopoly supplier characterized by some objective function over the quantity, quality and scope of services provided. The hospital maximizes this objective function/^{subject} to a break-even constraint.¹⁵ The models appear to be specified in this way in recognition of the non-profit character of most community hospitals and the fact that extensive insurance coverage and prevailing third-party reimbursement procedures make hospital admission demand function very inelastic with respect to price and mitigate price competition among suppliers. Yet none of these factors implies that non-price competition is unimportant.¹⁶ Patients must be sorted out among hospitals, so that there are good reasons to believe that hospitals do compete with one another for patients and that quality variables are important instruments for engaging in such competition when price competition is muted.

Assume that hospitals have some objective function over the quality and quantity¹⁶ of services provided to patients. The specific form of this objective function is not of much qualitative significance and it is convenient to think of it as total revenue or profits.¹⁷ Particular services

offered by the hospital have identifiable costs, but the hospital has some freedom to vary prices for particular services. Third party payers (Blue Cross, Medicare, Medicaid) probably put some constraint on how far above costs charges may be set¹⁸, however, as does the (perhaps limited) demand response of patients. Patients generally have some choice among hospitals in their area where care will be delivered. This choice may be largely articulated indirectly by the patient's choice of physician who will generally have admitting privileges at only one or two hospitals in the area. We can therefore view the physician as the agent for the patient and the "gate keeper" for who gets admitted to what hospital.

The relative charges of hospitals have a relatively small impact on choice among hospitals because of extensive insurance coverage. However, patients do value the quality and scope of services provided by the hospital and, other things being equal (like proximity), are likely to choose a hospital with greater quality and scope of services than the alternatives. Patients may articulate these preferences when making physician choices, so that one factor that will go into making the physician choice¹⁹ is the quality of the hospital at which the physician has admitting privileges. Therefore, to obtain patients and satisfy its quantity objectives in a market where other hospitals are trying to do the same thing, the hospital is likely to compete for patients by competing for physicians, who in turn, interested in securing patients themselves will be attracted to hospitals with higher quality services. The primary instruments that hospitals have for securing patients in competition with other hospitals will be variables that affect the quality and scope of services provided. The more intense is the competition for physicians and patients in an area, the greater the scope and quality of services is likely to be. In pursuing

its quantity objective the individual hospital must recognize that it is in competition with other hospitals and, with price competition muted, quality or scope of services becomes an important competitive instrument. The hospital's own objective for pursuing quality and scope of services would tend to reinforce these competitive effects.

This type of story seems to underly the conventional wisdom that the U.S. hospital system has a tendency to provide "excessive" quality and to be characterized by costly duplication of facilities providing different services. The probability of being turned away and the expected admission delay is a dimension of quality from the viewpoint of the hospital, the patient and his physician. Patients value getting prompt attention, physicians like to get their patients into the hospital quickly, and other things being equal, hospitals would rather admit more patients than fewer with full cost reimbursement. Furthermore, it has been suggested to me that the general quality of care provided by the hospital is better when the hospital operates well below its capacity constraints, when congestion problems ensue. In the context of the simple queuing model presented above, the reservation quality of the hospital represented by k is the quality variable that hospitals can manipulate.

This conceptual model of quality competition among hospitals is similar to that in price constrained airline models where prices are fixed and airlines compete with one another by increasing the reservation quality of their airlines by providing inefficiently high numbers of seats flying between city-pairs. Here, the non-price competition is motivated by the nature of insurance coverage and hospital reimbursement by third parties, but the effects are qualitatively the same.²⁰ This conceptual model is also related to the more general literature on monopolistic competition.

product quality and product variety.²¹

The intensity of competition among hospitals is, of course, very difficult to quantify in any precise manner. In the industrial organization literature, efforts to measure "competition" normally involve specifying a few structural variables, such as a concentration ratio and entry barriers, and to use data on transportation costs to define a "relevant" geographical market within which it is thought firms tends to compete with one another and within which these structural variables can be measured. As a general matter, our ability to measure the intensity of competition even in relatively simple product markets is limited. It is even more difficult for hospitals because of both conceptual and measurement problems. These difficulties include finding a useful definition of the relevant geographic market,²² measuring concentration ratios and entry barriers in such markets, accounting for differences in the nature of the "products" offered by different types of acute care hospitals, accounting for the agency relationship between patients and physicians and dealing with the competitive effects of different modes of health care provision, such as health maintenance organizations.

I have not attempted to construct variables which are refined measures of the structural characteristics of the hospital market for each observation in the sample. Data availabilities make this either extremely expensive or impossible, depending on the variable of interest. Rather, I have chosen three structural variables measured across individual states as crude preliminary measures of the extent of competition facing the hospitals in the sample. The underlying assumption is that the values of these variables are at least roughly indicative of the intensity of competition faced by all of the hospitals in the sample that are located in a particular state. The variables chosen are the following:

(1) The Herfindahl index based on the size distribution of hospitals within each metropolitan area in each state: This is meant to be a measure of market concentration.²³ If quality competition is a significant phenomenon I would expect that the higher is the Herfindahl index, the lower will be the equilibrium reservation quality of the hospital (HERF).

(2) The proportion of the insured population in the state that are members of health maintenance organizations: The role of health maintenance organizations as important sources of competition for the fee-for-service sector is well documented in the literature.²⁴ It is generally believed that HMO saturation fosters price (or cost) competition. However, with extensive insurance coverage, much of which is paid for by employers as a tax-free fringe benefit, it seems equally plausible that hospitals will respond to competition from HMO's, especially competition for physicians, by engaging in quality competition instead of price competition.²⁵ If this is true, I would expect the reservation quality of acute hospitals to be higher in states that have a greater saturation of HMO enrollment (HMO).²⁶

(3) The number of doctors per hospital in the area. As the number of physicians per hospital in the area increases, I expect that competition among hospitals for physician affiliations and referrals should become less intense. This is an admittedly crude effort to take account of the agency relationship between patients and physicians, the "gate keeper" role of the physician and the fact that a typical physician will have admissions privileges at only a limited number of hospitals (DRH).

B. Regulatory Effects

A number of states have been regulating hospital capacity additions directly through state certificate-of need (CON) legislation since the late 1960's. Today about forty states have certificate-of-need programs operating.

While the certificate-of-need process varies from state to state, these statutes usually require that hospitals obtain approval from a state agency before building a new facility or modifying an existing facility when the associated capital expenditures exceed some specified amount (usually \$100,000 or \$150,000).²⁷ I will not discuss these programs in detail here, but only point out that their objective is to constrain hospitals from building facilities which are not "needed." The concept of "need" is necessarily ambiguous. By and large, it appears that what the CON agencies are trying to do is to enforce some concept of efficient utilization of plant and equipment on the hospital sector. That is, given the demand for various facilities, the CON agencies try to insure that the number of facilities operating is just sufficient to satisfy demand at minimum cost.²⁸ To implement this notion, the states and the federal government have attempted to adopt utilization **criteria** for a variety of hospital facilities.²⁹ Initial attention of these agencies appears to have focused on "excess hospital beds" both because this was perceived to be a serious problem and because utilization criteria had already been developed as part of the Hill-Burton program.³⁰ Prevailing utilization criteria for hospitals are generally based on uniform target annual occupancy rates (80-90%) and area-wide bed/population ratios.³¹ The occupancy rate criteria can be applied to individual hospitals or to a health service area as a whole.

It may be convenient to think of the CON agency as a sort of government imposed "barrier to entry" or "incentive for exit." Since the primary determinant of increased bed supply over the past decade has been the expansion of existing hospitals rather than changes in the number of acute hospitals it appears that CON agency objectives would be pursued

primarily by constraining the expansion of existing hospitals and only to a lesser extent in affecting entry and exit of hospitals in the system. If the CON agencies have been successful in constraining the supply of beds, given demand, we would expect that the reserve margin (R) and the value of k should be smaller in states with CON regulation than in states without CON regulation. In the context of the simple queuing model presented above, this means that CON regulation should reduce the observed value of k.

The existence of CON regulation is measured here in three related ways:

(1) First, a dummy variable (CON1) is utilized which is equal to unity if a state had an operating CON program as of January 1, 1975 and zero otherwise. January 1, 1975 is chosen as a cutoff point since the data sample that is used here is for 1976 and as a result it is unreasonable to assume that a CON program could have an observable effect on the stock of beds without some lag.

(2) Second, a variable which takes on a value equal to the number of years that a CON program had been in effect as of January 1, 1976 (CON2) is utilized as an alternative measure of the intensity of this type of regulation. Since beds are a stock and CON agencies will probably primarily affect (to the extent that they have any effect) the flow of new bed construction, it is reasonable to hypothesize that the longer a program has been in effect, the greater will be its observed effects on the relationship between bed supply and expected hospital demand.

(3) Finally, a third variable (CON3) equal to the square of CON2 is introduced as another alternative measure. This introduces a non-linearity which allows us to capture both the "stock effects" of older CON programs and "learning" effects which might allow a CON agency to become more effective over time.³²

Certificate-of-need regulation is not the only form of state regulation that has the potential to affect bed supply decisions. By 1975 nine states had state rate-setting commissions with responsibilities to approve hospital charges for at least some classes of patients.³³ While the procedures used for approving hospital charges vary from state to state, as does patient coverage, the general approach is to try to set hospital charges using some type of "prospective" reimbursement system. Basically, the idea is to set next year's rates based on some target level for hospital expenditures. The target level is generally based on a formula which integrates historical cost and utilization patterns, adjustments for inflation and changes in patient volume, and target utilization rates for particular types of facilities. In addition to the nine states which have state rate-setting commissions, the Blue Cross plans in another fifteen states had implemented some form of prospective reimbursement system by 1975 as well.³⁴

At least in theory, if a prospective reimbursement system is actually successful in constraining a hospital's expenditures in some way, a supply response would be induced. In particular, combining a utilization rate criterion (like an 80% occupancy rate for medical and surgical beds) with a reimbursement formula that provided for reimbursement on the assumption that the utilization criterion was being achieved,³⁵ could provide strong incentives for hospitals to achieve the utilization criteria if cross-subsidization is properly restricted.

To examine the effects of prospective reimbursement systems, a dummy variable DPR is introduced which takes on the value 1 if the state in which the hospital is located has either a state-run or Blue Cross-run prospective reimbursement system and a value of zero otherwise. The time effects and the learning effects hypothesized for CON regulation have not been

incorporated for prospective reimbursement because data on the length of time programs have been in effect were not available to me for more than a fraction of the states which have such programs.

If CON regulation or prospective reimbursement has been successful in constraining bed supply decisions we would expect that the value of k should be lower in those states where these regulatory programs are in effect.

The variables chosen to represent the intensity of competition between hospitals and state regulation have been entered interactively with the square root of average daily census in (5) so that the estimated coefficients give as an estimate of the impact of competition and regulation on the value of k , the reservation quality of the hospital. The estimating relationship then becomes:

$$(6) R = \sqrt{ADC} (k_1 + aHERF + bHMO + cDRH + dCON.i + eDPR) + u$$

$$\hat{K} = \hat{k}_1 + \hat{a}HERF + \hat{b}HMO + \hat{c}DRH + \hat{d}CON1 + \hat{e}DPR$$

if non price competition and regulation affect reservation quality as hypothesized we expect that the estimated coefficients would have the following signs:

$$a < 0, \quad b > 0, \quad c < 0, \quad d < 0, \quad e < 0.$$

The estimated values of the coefficients of (6) are reported in Table 2 for each of the measures of intensity of CON regulation. Standard errors are reported below the coefficient estimates. Estimates of an unconstrained version of (6), using CON3, are also reported for comparison.³⁶ Finally, it has been suggested that the number of doctors per hospital may be an endogenous variable in a larger system where doctors migrate to regions in

Table 2

Estimated Coefficients of Reserve Margin Relationship

	k_1	a	b	c	d	e
CON1	5.18 (0.30)	-12.29 (5.52)	0.027 (0.023)	-0.0013 (0.0024)	-0.46 (0.23)	-0.98 (0.26)
CON2	5.10 (0.28)	-11.56 (5.21)	0.073 (0.024)	-0.0026 (0.0024)	-0.17 (0.027)	-0.65 (0.24)
CON3	4.74 (0.25)	-10.94 (5.24)	0.078 (0.023)	-0.0032 (0.0025)	-0.016 (0.0026)	-0.37 (0.26)
CON3(IV)	4.81 (0.27)	-11.76 (5.11)	0.077 (0.023)	-0.0026 (0.0023)	-0.017 (0.0023)	-0.45 (0.24)

$$\text{Mean(HERF)} = 0.043$$

$$\text{Mean(HMO)} = 2.67$$

$$\text{Mean(DRH)} = 64$$

Unconstrained Relationship (with CON3):

$$\text{Beds} = -4.12 + 0.98\text{ADC} + \sqrt{\text{ADC}} (5.51 - 10.83\text{HERF} + 0.072\text{HMO} - 0.004\text{DRH} - 0.015\text{CON3} - 0.37\text{DPR})$$

(4.23) (0.026)
(0.76) (5.27)
(0.022) (0.0031)
(0.0029)

(0.26)

$$R^2 = 0.98$$

which the quality of hospitals is higher. Instrumental variable estimates of (6), for the CON3 version, are therefore also reported in the table.

The signs of the estimated coefficients are uniformly consistent with the hypotheses that inter-hospital competition induces hospitals to choose a higher value of k or higher reservation quality and that state certificate of-need regulation and prospective reimbursement constrain hospital bed supply decisions so as to reduce the reservation quality of the hospital. Most of the coefficients are estimated fairly precisely as well. The doctors per hospital variable tends to be the least significant and generally insignificantly different from zero at the 5% level. Comparing the estimates of (6) with the "unconstrained" version of it is fairly reassuring. The constant term is not significantly different from zero (the first constraint) and the coefficient of ADC is not significantly different from unity (the second constraint). The estimates of the other coefficients are generally similar to those estimated from the underlying relationship derived from the simple queuing model.

The magnitudes of the estimated coefficients are also of some interest. Let us consider the regulation variables first. The most convenient way to do this is to compare the estimated value of k without either type of regulation with the estimated value of k when regulation is present: k_r and k_{nr} , respectively. These estimates are reported in table 2 where k_{nr} is derived under the assumption that CON_i and DPR are zero and k_r is derived under the assumption that CON_i is set at its mean value for states that have such regulation and DPR is set at unity. In both cases, the other variables are set at their mean values.

The average difference between k_{nr} and k_r is about 1.25 standard deviations. For a hospital with an average daily census of 200, this implies that on average regulations of these types reduce the supply of beds by 5% to 8% other things

Table 3

The Effects of Regulation on the Value of k

	<u>k_{nr}</u>	<u>k_r</u>
CON1	4.64	3.20
CON2	4.62	3.07
CON3	4.27	3.30
CON3(IV)	4.31	3.31

equal. The impact on hospital costs would be substantially less as a proportion of total hospital expenditures since "marginal savings" from eliminating beds is probably far below the average total cost per bed.³⁷ Nevertheless the application of mean levels of regulation across all states could easily imply savings of \$1 billion per year (based on 1976 expenditures)³⁸ compared to the case of no regulation at all.

The estimated values of two other variables are worth further examination as well. The mean value of the Herfindahl index across states is about 0.05. However, the highest value is 0.33. Other things equal, an area with a Herfindahl index of 0.25 would have an estimated value of k that is over two standard deviations less than the mean. It is therefore conceivable that CON regulation can have an indirect effect on the value of k by forcing hospitals to exit from the market, increasing concentration and reducing non-price competition. That is, greater emphasis might be put on closing hospitals and less emphasis on controlling the expansion of existing hospitals. Of course, this approach raises difficult legal and political issues which are beyond the scope of this paper.

The estimated values for the coefficient of the HMO variable is also of some interest. There has been a traditional feeling that by encouraging the development and growth of health maintenance organizations, the additional competition that results would serve to increase price and cost competition among providers. This view presumes that individuals join health maintenance organizations because they offer lower-cost medical care. It is equally plausible that patients and physicians choose HMO's because they prefer the mode or quality of care that such organizations provide. If this is the case, increased competition from HMO's may induce hospitals to engage in quality competition rather than price competition, perhaps emphasizing those aspects of quality which HMO's tend to avoid. In any case, this is what the

results in table 2 seem to show. HMO enrollment in some states is over 20% of the insured population. The estimated value of k with HMO enrollment set at 20% is over one standard deviation higher than for the mean state, other things equal. However, since HMO's appear to deliver medical care at per patient costs substantially below those in the fee-for-service sector, the net effects on total costs of this type of non-price competition would be very difficult to determine.³⁹

Some Qualifications to the Simple Queuing Model

It is tempting to go further than drawing positive implications about quality competition and regulation from the previous analysis and to use the estimates of k presented above in a normative analysis which tries to assess the optimality of prevailing levels of hospital capacity. Such an analysis might proceed by comparing the marginal cost per additional patient that is not turned away at particular values of k , drawn, for example, from tables 1 and 3 with estimates of the value to the marginal patient of not being turned away. In this way, an optimal value of k might be determined and compared with the actual values of k without regulation. If the actual value of k is larger than the optimal value of k , the social cost of excess hospital capacity could then be determined. Some health planning agencies and some policy analysts have in fact used this basic model to make policy decisions and to compute the costs of excess beds.⁴⁰

There are a number of reasons to believe that estimated values of k based on empirical specifications using this simple queuing model should be used for this type of normative analysis only with great caution, however. Caution is required because the simple queuing model that has been utilized embodies a number of simplifying assumptions which may not be completely consistent with reality and as a result, the estimated value of k may overestimate or underestimate the true reservation quality of the hospital.

Of special concern are the following:

(1) Arrivals are not truly random over the year as the Poisson arrival process used in this formulation assumes. More arrivals are clustered on weekdays than on weekends and there is a predictable seasonal variation in the utilization of hospital facilities. As a general matter, it appears that the daily census tends to be relatively high during the week and relatively low on weekends (unfortunately, daily census data are not generally available). For example, figure 1 shows the variation in the daily occupancy rate for a typical community hospital during the peak week of the year.⁴¹ Monday through thursday is characterized by relatively high occupancy rates. Occupancy rates fall sharply on weekends. Hospital utilization also varies from month to month. In figure #2 is exhibited the average number of admissions per day in U.S. community hospitals for 1977.⁴² The average number of admissions per day in March is about 20% higher than in December. (Christmas tends to be the slackest period of hospital utilization during the year. But slack periods may also accommodate vacation time for hospital personnel.)

The daily fluctuations in demand reflect prevailing admission patterns and the distribution of hospital lengths of stay. Elective admissions appear to be concentrated early in the week and approximately 50% of all admissions remain in the hospital four days or less.⁴³ Late-week admissions and weekend admissions are apparently much less prevalent for elective procedures, reflecting patient and physician preferences. This pattern also allows hospital staffing patterns better to reflect typical five-day week work schedules. Substantial reductions in hospital staffing on weekends is permitted as a result of the lower utilization rates during these periods of time. Month-to-month fluctuations reflect both the incidence of diseases

for which hospitalization is required as well as a strong tendency to avoid elective admissions during vacation periods.

Based on these additional characteristics of hospital utilization, it seems clear that estimates of k based on this simple queuing model, using the average daily census average over 365 days will tend to underestimate the probability of being full when patients and physicians seek admission to the hospital and therefore overestimate the reservation quality of the hospitals. Another way of thinking of this is to view the average weekday census (ADC*) as the relevant planning variable, not the average daily census over all days of the year. Unfortunately, daily census data are not generally available.

To obtain some sense for the effect of this factor on the estimated reservation quality of the hospital, equation (6) (with CON3) has been reestimated under the assumption that the relevant expected demand (ADC*) for planning purposes is higher than observed ADC by 25% of the average reserve margin of the hospital. Under this assumption, the estimated relationship becomes

$$R = \sqrt{\text{ADC}^*} \quad (2.47 - 8.01\text{HERF} + 0.051\text{HMO} - 0.0023\text{DRH} - 0.011\text{CON3} - 0.25\text{DPR})$$

$$(0.19) \quad (3.62) \quad (0.015) \quad (0.0021) \quad (0.002) \quad (0.18)$$

The estimated value of k_{nr} is now 2.11 and the estimated value of k_r is not 1.49. Both values are substantially lower than were estimated without making this experimental change in the relevant expected demand variable.

(2) The simple queuing model utilized here assumes that the hospital can be viewed as a single organizational entity where all beds are perfect substitutes for one another. However, in reality, the hospital is often composed of several distinct patient facilities (medical, surgical, intensive

care, obstetric, pediatric, etc.) whose beds are not perfect substitutes for one another; admissions decisions may be made separately for each distinct patient facility (DPF). As a result, the demand characteristics and bed supply of each individual facility are relevant for planning purposes, not necessarily the aggregates for the hospital as a whole. The distinction between DPF's and the hospital as a whole has generally been recognized in the operations research literature which often focuses on DPF's.⁴⁴ However, this point seems to have been lost entirely from the efforts to use such models to make normative judgments about hospital bed supplies. Treating the hospital as an aggregate will generally overestimate the reservation quality of the hospital as viewed by the distinct patient facilities.

For example, the Commonwealth of Massachusetts had the following breakdown of beds in various categories in 1977:

Table 4

Medical/Surgical Beds	20,496
Medical/Surgical ICU Beds	985
Medical ICU Beds	105
Surgical ICU Beds	110
Cardiac Care Unit Beds	283
Pediatric ICU Beds	45
Respiratory ICU Beds	22
Neonatal ICU Beds	111
Burn ICU Beds	40
Orthopedic ICU Beds	120
Pediatric Beds	2,315
Maternity Beds	1,533
Psychiatric Beds	832
Other	1,100

Source: Massachusetts Department of Public Health

It should be noted that these data make no effort to distinguish medical and surgical beds that are operated as distinct patient facilities. Yet, even if bed space is available, it makes little sense to admit a surgical patient if space in the operating rooms is not available. The general point is that the internal organization of the hospital is likely to have important implications for assessing the reservation quality of the hospital. It is also the case that the number of distinct patient facilities and the substitutability of beds dedicated to different services will vary widely from hospital to hospital.

In an effort to assess the potential qualitative implications of internal organizational considerations on the estimated reservation quality of the hospital equation (6) (with CON3) has been reestimated under the assumption that each hospital has two major distinct patient facilities of equal size and with the same target values for k .⁴⁵ It may be convenient to think of this as a separation between medical and surgical facilities since about 40% of hospital patients are surgical patients.⁴⁶ The estimated relationship becomes the following:

$$R = \frac{2\sqrt{ADC}}{2} \begin{matrix} (2.42 - 7.85\text{HERF} + 0.05\text{HMO} - 0.0025\text{DRH} - 0.11\text{CON3} - 0.26\text{DRH}) \\ (0.19) \quad (3.89) \quad (0.015) \quad (0.0021) \quad (0.002) \quad (0.18) \end{matrix}$$

Using this relationship the estimated value of k_{nr} is 2.06 and the estimated value of k_r is 1.43. Once again, these are both substantially below the estimates made without accounting for distinct patient facilities.

(3) The queuing discipline assumed in the simple queuing model may be too simplified. For example, emergency patients and elective patients may be queued differently and bed utilization managed so as to make the probability

of turnaway for emergency patients very low, while increasing waiting time for elective patients. That is, patients need not leave the system, but can be put on a waiting line, and admissions can be managed so as to minimize the turnaway probability for emergency patients (for example by queuing elective patients before all beds are full), which is presumably most costly. Queuing models such as this exist in the operations research literature, but they are very complicated.⁴⁷ It is unlikely that hospitals actually follow the normative prescriptions of such models except in a very rough way. As a general matter, if patients are queued in this way, at least from the perspective of emergency patients the estimated values of k obtained from (5) and (6) would tend to underestimate the actual reservation quality of the hospital. Current data make the quantification of these effects impossible except using simulation models.

As with any simple model used to describe the behavior of a complex organization the simple queuing model used here fails to deal completely with all aspects of hospital demand patterns, internal organization and admissions behavior. Nevertheless, the model seems to be a useful vehicle for performing positive analyses of the extent of non-price competition and the effects of state regulation. Normative analysis aimed at estimating an optimal value for k and comparing it with the actual value of k should proceed with more caution.

Conclusions

The bed supply decisions of community hospitals have important implications for both the costs of hospital care and the reservation quality of the hospital system. The hospital's bed supply decision must be conceptualized in the

context of the stochastic characteristics of hospital demand. Given demand, the more beds that a hospital supplies, the lower is the probability of being turned away and the shorter are delays in admissions. The bed supply decision is inherently a quality decision as well.

The simple queuing model which forms the basis for the empirical work reported here provides a useful framework for performing positive analyses of quality competition among hospitals and the effects of regulation, given the available data on bed supplies and hospital utilization. The intensity of interhospital competition as measured here appears to have a significant and potentially important quantitative effect on the equilibrium reserve margin and reservation quality of hospitals. The empirical results indicating that higher market concentration reduces quality competition and leads to lower reserve margins is of some general theoretical interest in the context of the existing literature on the performance of price constrained airline markets and recent theoretical work on monopolistic competition. It also has potentially useful policy implications. The results suggesting the hospitals may respond to competition from health maintenance organizations by increasing quality rather than by reducing quality and the cost of care raises interesting questions about the effects of promoting expansion of HMO's without also reforming the way insurance policies are written and the way individuals purchase and pay for their health insurance.

The results also indicate that certificate-of-need regulation and efforts to regulate hospital budgets and rates using prospective reimbursement criteria have had a significant impact on hospital bed supply decisions. These results are at least partially consistent with other efforts to assess these types of regulations using different empirical methodologies.

However, whether these regulations actually help to reduce total costs or whether they merely divert incentives for increased quality from beds to other aspects of hospital care remains uncertain. Other work indicates that the primary effect of certificate-of-need regulation may be to substitute investment in other types of equipment for beds.⁴⁹

The empirical estimates presented using the specification derived from the simple queuing model indicates that hospitals, unconstrained by regulation, supply beds to a point where the number of beds is over four standard deviations from the mean demand. Such a high reserve margin would be virtually impossible to justify on cost/benefit grounds. However, since the underlying queuing model is based on assumptions about the distribution of arrivals and the internal organization of the hospital which are likely to be inconsistent with reality, great care should be used in drawing normative implications from these point estimates. In any case, if planning agencies are going to use models such as this for establishing bed supply regulations, better data on daily admissions patterns for distinct patient facilities should be developed. Reliance on aggregate data is likely to yield an overestimate of the actual reservation quality of the hospital.

These conclusions are suggestive, but certainly not definitive. A relatively small random sample of hospitals was used in the analysis here; the simple queuing model on which the empirical analysis is based has problems which have been acknowledged; the intensity of competition between hospitals has been measured very crudely; detailed differences between state regulatory programs have not been accounted for. However, the results are sufficiently suggestive that further work examining the bed supply decision, quality competition and regulation, in the context of more comprehensive stochastic models that account for daily admission patterns and internal organization characteristics of hospitals, seems justified.

PEAK WEEK FOR TYPICAL HOSPITAL

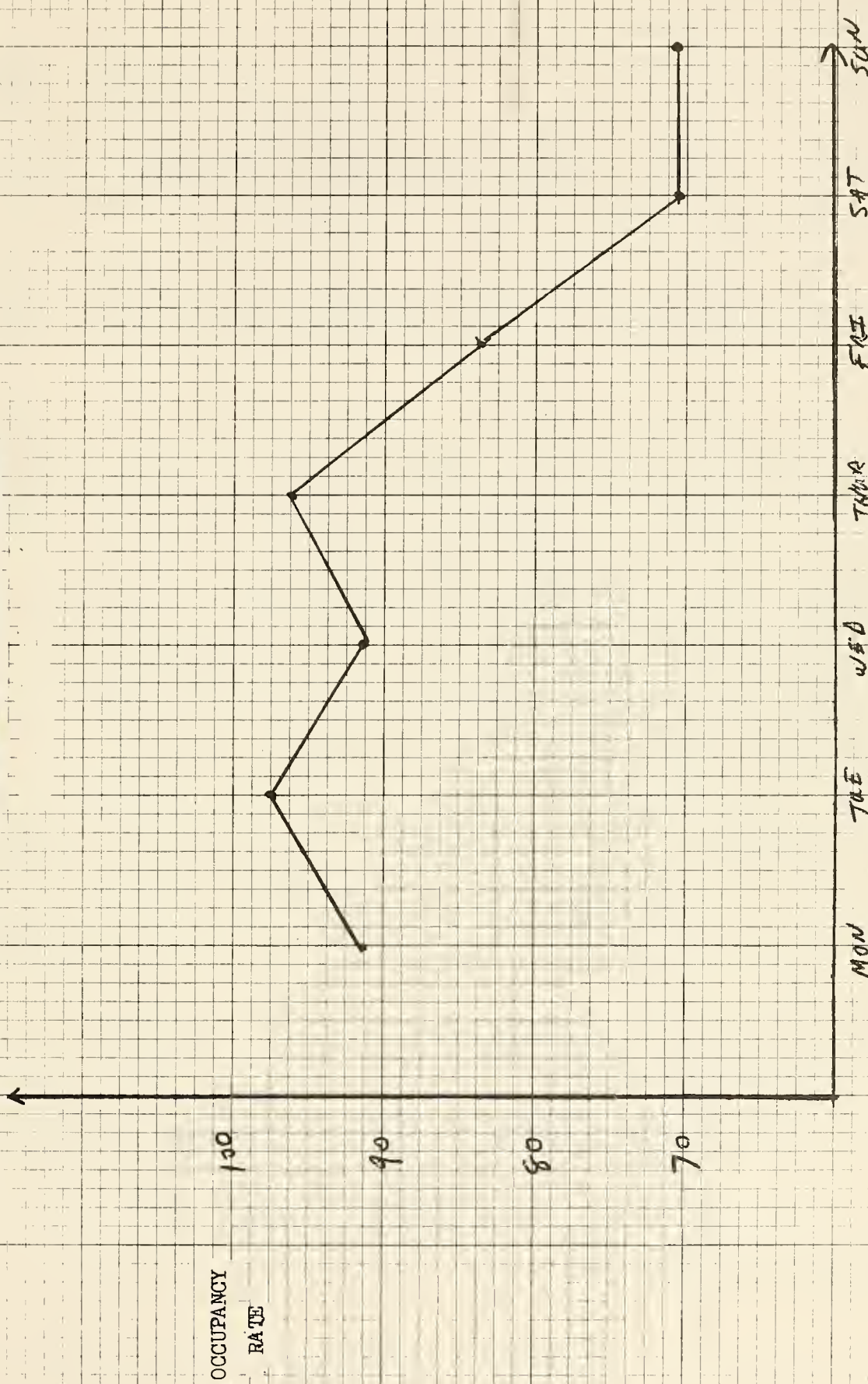


FIGURE #1

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AVERAGE DAILY ADMISSIONS
(U.S. Community Hospitals)
1977

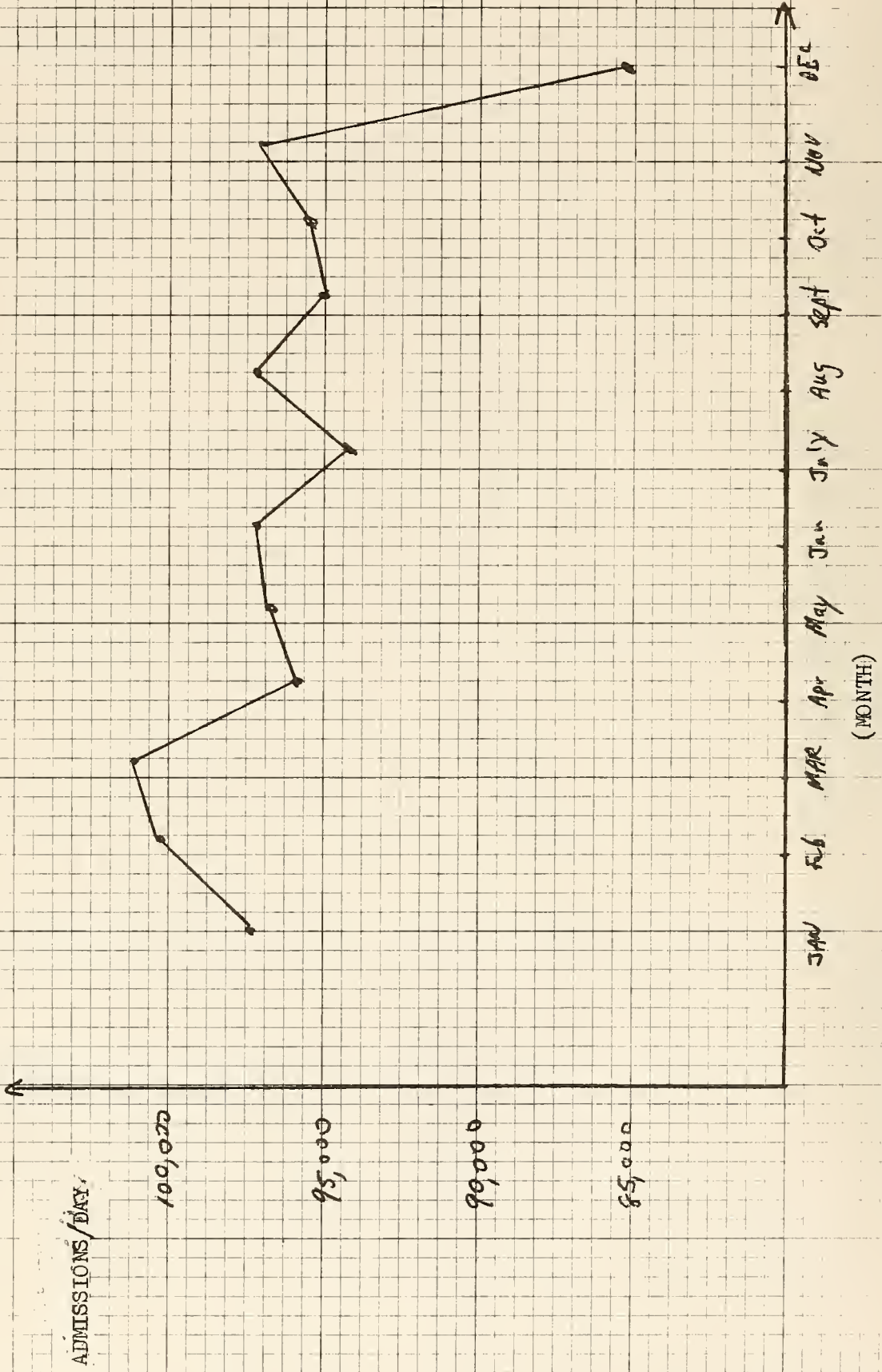


FIGURE #2.

Notes

¹Feldstein (1971) and (1977).

²See, for example, McClure and the National Guidelines for Health Planning, Federal Register, March 28, 1978, Part IV, p. 13046.

³See Hospital Statistics, 1977 Edition, American Hospital Association, Chicago, IL.

⁴Shonick (1970) and (1972), Melum, Bureau of Health Planning and Development, Connecticut State Department of Health, Draft: Projection Formulas (Hartford, June 1977) and McClure, pp. 17-20.

⁵Cooper, p. 65.

⁶The same results can be derived for any length-of-stay distribution function with a finite mean. Note that we take the demand on the system as given and do not consider whether this demand is "too large" or "too small," given some specific normative criterion.

⁷It is interesting to note that this queuing model with a large (an infinite bed model) yields the same probability distribution as another queuing model in which patients are queued up rather than turned away when the hospital is full. In the latter model, a patient is assumed to wait for service for as long as time T. If a bed opens up before T has elapsed the patient will spend the remainder of time in the hospital. See Cooper, pp. 77-79. Given the assumptions of the simple queuing model used here, the use of (3) based on observed average daily census data appears to be a good approximation to (1) and (2). See Shonick, p. 1495.

⁸After the first version of this paper was written Jeffrey Harris brought a paper by Joseph and Folland to my attention. They use an empirical specification identical to (4) and (5) for a sample of Iowa hospitals for 1969. However, they do not derive this specification from a specific queuing model and do not go on to consider the effects of competition and regulation on k.

⁹See Lipscomb et al. for a review of the econometric evidence.

- ¹⁰(1) $\sum_{ADC=(B^*+1)}^{\infty} (ADC-B^*) P(ADC)$ Expected number of patients turned away per day for a hospital with B* beds, and expected daily demand of ADC.
- (2) $\sum_{ADC=(B^*+2)}^{\infty} (ADC-(B^*+1))P(ADC)$ Expected number of patients turned away per day for a hospital with (B*+1) beds.
- (3) $(365) \times \sum_{ADC=(B^*+1)}^{\infty} P(ADC) = (365)[(1)-(2)]$ Reduction in expected number of patients turned away per year by increasing beds from B* to (B*+1).
- $\sum_{ADC=(B^*+1)}^{\infty} P(ADC)$ is given by k.

¹¹This point does not appear to have been recognized in the hospital cost function literature.

¹²The Hill-Burton formula of 80% or 85% has this uniformity characteristic. The Commonwealth of Massachusetts uses a uniform target occupancy rate of 90%. See Massachusetts Determination of Need Guidelines, Department of Public Health, November 26, 1976.

¹³In 1976 the ADC for nonmetropolitan hospitals was 58 and for metropolitan hospitals it was 211. See Hospital Statistics, American Hospital Association, 1977 edition, p. 148.

¹⁴Note that an "unconstrained" version of this empirical specification would be

$$\text{Beds} = a_1 + a_2 \text{ADC} + k\sqrt{\text{ADC}}$$

Estimates for the unconstrained linear relationship are presented below after the full model, including variables reflecting the intensity of competition and regulation, are introduced. The estimated values of k reported here can be compared with Joseph and Folland's estimate of 3.22 for Iowa hospitals in 1969.

¹⁵See Feldstein (1971) and (1972), Newhouse (although he also discusses the role of entry and some "large group" considerations) Long and Lee. Davis assumes that the hospital is profit seeking. Pauly and Redisch assume that the staff physicians run the hospital so as to maximize their own incomes (they also include a brief discussion of long-run equilibrium in which physicians can move from hospital to hospital and new hospitals can be formed.)

¹⁶The words quantity and quality are used in a variety of ways in the hospital economics literature, so I would like to make clear what I mean by these terms. I am thinking of the hospital as an organization that offers a bundle of diagnostic and therapeutic services to the patient. These would include medical and surgical nursing care, laboratory services, radiology services, intensive nursing care, various types of surgical capabilities, special pediatric care, obstetrical care, etc. The variety of services offered can differ from hospital to hospital. When I use the term quantity I am referring to the number of units of each of these services that is provided by the hospital. As a general matter, the more patients that are admitted to a particular hospital with a particular variety of services the greater will be the quantities of some or all of these services provided. This conceptualization is related to Harris' discussion of the internal organization of a hospital. When I use the word quality I am referring to two dimensions of the services provided by the hospital. First, the scope of services offered by the hospital as measured by some function of the number and types of services offered. Other things equal, the more services provided the greater is the scope of services and the greater is the "quality" of the hospital in this dimension. Second, each of the services can be provided with different levels of quality. For example, the number and training of nurses can be varied in the nursing units; a hospital may have a full complement of house staff or it may not; the turnover probability and service delay may be increased or decreased by changing the staff and capital equipment available to provide different services. Thus "quality" has two very different dimensions. I am assuming that physicians and patients value the quality of the hospital in both dimensions.

I am working on a more complete model of individual hospital and market behavior which reflects this type of specification. At this stage it appears that this framework allows me to deal with a number of behavioral and performance characteristics of hospitals in useful ways. These include considerations of the effects insurance-induced increases on the demand for services, the separation of static changes in quality from technological change, market equilibria characterized by a failure to exploit economies of scale and detailed consideration of the effects of price regulation and certificate-of-need types of planning regulation aimed at facility consolidation, on the variety of services offered and the efficiency with which they are offered. I hope that this work will be completed soon.

¹⁷At this point, this statement is a conjecture rather than a firm conclusion. As I read the hospital economics literature, considerable effort has been directed towards defining particular hospital objective functions. It appears to me that these efforts are at least partially related to a desire to get two types of results from the theoretical models. First, that hospitals will tend to oversupply quality. Second, that hospitals break even--that is, the hospital as an organization does not earn any economic rents when it perceives demand functions (rather than just prices) for its services. It seems to me that the same sorts of qualitative results can be obtained by making the assumption that hospitals maximize revenue subject to a break-even constraint, where prices can be charged for particular services, where patients and physicians value both quantity and quality (as discussed above) and where insurance coverage increases demand beyond the optimal level. Indeed, if we place the hospital in a monopolistically competitive market, under the same assumptions, a profit maximizing objective may do as well since inter-hospital competition will tend to drive profits toward zero. In this case, we could get both too much quality and zero profits even with the optimal amount of insurance, recognizing in this case, that the "optimal" amount and distribution of quality and quantity will be a second-best optimum given the tradeoff between the risk spreading benefits of insurance and the costs of any associated consumption distortions.

¹⁸For example the Medicare reimbursement system tries to reimburse hospitals only for "actual" costs incurred by requiring hospitals to provide a detailed accounting allocation of both direct and indirect costs associated with particular services and then reimbursing only for these costs even if the posted charges of the hospital are above or below these levels. As with any cost allocation system such as this, there is some room for "arbitrary" allocations, but the increasingly detailed allocation criteria certainly limit hospital discretion here.

¹⁹We know relatively little about how patients choose physicians. Hospital affiliation should be one factor that goes into this determination. It also appears that many individuals do not have a regular physician, relying on hospital emergency rooms and outpatient clinics and free-standing ambulatory care facilities. In the first two cases, patients choose their hospital directly. Regular physicians will also refer patients to other physicians affiliated with the same or a different hospital, depending on what the particular medical problem is and the extent to which the physician acts as a "perfect" agent for the patient.

²⁰See for example, Douglas and Miller and Schmalensee (1977a).

²¹See for example Spence and Dixit and Stiglitz.

²²There is some evidence that patients tend to use hospitals closest to their homes. See Marrill et al. and Drosness and Lubin. Because of referral patterns and varying service scopes, however, the geographic market in which individual hospitals compete is difficult to define or measure.

²³See Schmalensee (1977b).

²⁴See Enthoven and Goldberg and Greenberg.

²⁵Most of the discussion of HMO's has focused on the patient and the ability of these organizations to attract patients. The ability of such organizations to attract physicians is also important. The mode of practice must appeal to them and appropriate levels of compensation must be offered. Comparisons of the behavior of HMO utilization patterns with those in the fee-for-service sector have often been concerned about whether the patient population served by the HMO is a representative one. Of additional concern is whether the physicians who currently practice in the limited number of HMO's are representative of the physician population.

²⁶This may be especially true here since it is sometimes argued that HMO's limit demand by imposing long queues for non-emergency patients (as I am told is also the case in England under the National Health System). Hospitals may respond to HMO competition by focusing on the characteristics of HMO's which many patients and physicians find particularly unattractive.

²⁷See Lewin and Associates, Nationwide Survey of State Health Regulations, September 1974, National Technical Service, Havinghurst and Curran.

²⁸CON agencies appear to take demand as given in evaluating applications. Projections of hospital utilization are made over some future time period and the various occupancy rate or bed/population criteria are then applied to yield the "appropriate" number and distribution of facilities. CON agencies therefore view "need" from the supply side, in terms of minimum cost production, rather than from the demand side, in terms of whether the demands observed or projected are in some sense "justified." See, for example, the Massachusetts Health Planning Guidelines, parts 6-65. See also Ledley et al. However, there remains a notion that by constraining bed supplies, utilization will be affected as well, although this feedback effect does not appear to have been folded into the CON process in a formal way.

²⁹See National Health Planning Guidelines 42 CFR 121.201-121.211.

³⁰See Bicknell and Walsh.

³¹As indicated above, the Hill-Burton formulas involved an 80 or 85% annual occupancy rate target and Massachusetts guidelines apply a 90% average annual occupancy rate.

³²For example, the certificate-of-need program was established in Massachusetts in 1972. Amendments to the certificate-of-need regulations in 1974 sought to make choice criteria more explicit and formal standards for acute care hospitals were not officially incorporated into the regulations until 1976. In an unpublished report Bicknell and Van Wyck report that the approval rate for hospital projects in Massachusetts decline from 95% in 1974 to 75% in 1977. ("Certificate of Need: The Massachusetts Experience, January 1974-June 1977" by William J. Bicknell and Judith Van Wyck.)

³³Lewin and Associates, op. cit. supplemented by data obtained from the Department of Health, Education and Welfare.

³⁴Ibid.

³⁵For example, let's say that the regulatory agency wants obstetrical units to achieve a 70% average annual occupancy rate. Reimbursement rates are then calculated using the actual occupancy rate for units with rates above 70% and impute an occupancy rate of 70% to those facilities which have lower occupancy rates. Those facilities with lower occupancy rates either have to close or subsidize the obstetric facility with revenues from other services or from philanthropic contributions. New York state has taken this approach. However, applying this approach to all facilities may yield undesirable outcomes if hospitals have some flexibility to increase average lengths of stay or to draw more patients into the hospital. California is an interesting case in point. The National Guidelines establish an 80% occupancy rate criterion and a maximum of four beds per thousand population for each Health Service area. In 1976 California had an average annual occupancy rate of only 65.6% but also had only 3.8 beds per 1,000 population. In addition California had an average length of stay that was far below the national average. It would be counterproductive if California ~~responded~~ ^{hospitals} to these regulations by increasing their average lengths of stay so as to increase the annual occupancy rate rather than responding by reducing the number of beds.

³⁶The unconstrained linear relationship takes the following form:

$$\text{Beds} = a_1 + a_2 \text{ADC} + \text{ADC}(k_1 + a \text{HERF} + b \text{HMO} + c \text{DRH} + d \text{CON3} + e \text{DPR})$$

³⁷See Lipscomb, Raskin and Eichenholz for a review of the econometric literature. The studies that appear relevant for doing this type of calculation imply a longrun marginal savings of between 10% and 40% of the average total cost per bed.

³⁸In 1976 the average total cost per bed in community hospitals was \$41,000. If we assume that the long-run marginal savings per bed is equal to 25% of this amount and that the combined efforts of CON and rate regulation applied nationwide reduced the number of beds by 6% the aggregate savings would be about \$700 million per year. I have not yet been able to compile useful and complete data on the administrative costs of these programs so I am not in a position to comment on the net savings. It does seem clear that these programs aren't making a very large dent in the hospital cost explosion when we recognize that real hospital expenditures increased by about \$4 billion between 1976 and 1977.

³⁹See Luft.

⁴⁰Bureau of Health Planning and Development, Connecticut State Department of Health, Draft Projection Formulas (Hartford, June 1977), McClure, pp. 17-20, and Melum.

⁴¹Daily census data are not generally available for individual hospitals. This figure is based on daily census data that I have examined for three community hospitals.

⁴²Source: American Hospital Association, Hospital Indicators. See also Ledley et al., figure 2.

⁴³Utilization of Short-Stay Hospitals: Annual Survey for the United States, 1976. National Center for Health Statistics.

⁴⁴Shonick (1970) and (1972).

$$\text{BEDS}_m - \text{ADC}_m = \sqrt{\text{ADC}_m} (k_1 + \dots)$$

$$\text{BEDS}_s - \text{ADC}_s = \sqrt{\text{ADC}_s} (k_1 + \dots)$$

$$\text{BEDS}_m + \text{BEDS}_s - \text{ADC}_m - \text{ADC}_s = (\sqrt{\text{ADC}_m} + \sqrt{\text{ADC}_s}) (k_1 + \dots)$$

$$\text{ADC}_m = \text{ADC}_s = \text{ADC}/2$$

⁴⁶Utilization of Short Stay Hospitals: Annual Survey for the United States 1976. National Center for Health Statistics.

⁴⁷See Shonick and Jackson.

⁴⁸Salkever and Bice found that CON regulation constrained investment in beds, but did not retard total hospital expenditures. Hellinger found that CON regulation did not constrain hospital investment, but he does not disaggregate.

⁴⁹Salkever and Bice.

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