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# The Relationship between Capacity and Utilization in Hospitals

Lawrence Wu  
Doctoral Candidate  
Graduate School of Business

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THE RELATIONSHIP BETWEEN  
CAPACITY AND UTILIZATION IN HOSPITALS

Lawrence Y. Wu  
Graduate School of Business  
University of Chicago

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## ABSTRACT

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Author: Lawrence Y. Wu  
Graduate School of Business, University of Chicago

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This paper analyzes the capacity investment decision of hospitals and the relationship between capacity and utilization. The goal is to examine a general model of hospital cost inflation where hospitals respond to increases in revenue by expanding capacity and increasing quality. Spiraling costs may result if these increases in quality lead to further increases in demand. The paper focuses on the effects of non-profit, for-profit, and public ownership in an effort to determine whether and how the rise in hospital costs is affected by organizational incentives. The theoretical results suggest that public and non-profit hospitals will overinvest in capacity relative to for-profit firms and that they will respond to increases in revenue with relatively larger increases in capacity. The empirical work confirms these results. Analysis of aggregate time-series and cross-section data also suggest that a given increase in capacity leads to a greater increase in utilization in public and non-profit hospitals. In sum, the results suggest that organizational incentives in public and non-profit hospitals may lead to significant inflation. The rise in hospital costs may be higher in these two ownership categories for two reasons. First, a given increase in demand leads to the greater costs associated with a larger investment in capacity. Second, a given expansion in capacity leads to the greater costs associated with a larger increase in utilization.



## SECTION I. INTRODUCTION

Capacity?

The rise in hospital costs continues to be a major issue in public policy. The perceived inefficiency associated with underutilized bed capacity, the duplication of facilities and services, and the lack of incentives to use medical resources efficiently have led to extensive rate regulation and controls on hospital capital investment.

The regulation of hospital bed supply in the United States has been influenced heavily by an empirical relationship known as "Roemer's Law". An accepted stylized fact is the high correlation between hospital utilization and the supply of hospital beds in a given area. Shain and Roemer (1959) were the first to argue that the fundamental determinant of hospital utilization is the supply of beds. Roemer (1961) provided further evidence by documenting the increase in utilization, as measured by the number of admissions and average length of hospitalization, experienced by a community hospital after a major expansion of beds. He concluded that the effective control of the amount of money spent for hospitalization lies in the regulation of hospital bed supply. With extensive insurance coverage in the population, he argued that an "excess" number of beds may lead to an inefficient provision of health care; patients are hospitalized even when less costly, but adequate, treatment is available in physicians' offices or outpatient clinics.

Although correlation does not imply causation, belief in Roemer's Law has led to extensive government regulation of hospital facilities and capital expansion. Certificate-of-need (CON) programs, for example, were developed by individual states in the late 1960s in an effort to reduce the number of "excess" beds. Regulators tried to limit the number of hospital beds in an area to satisfy a fixed bed/population ratio and an average occupancy rate. Since 1987, however, several states have discontinued their CON programs and many more CON programs are set to expire in 1991. Any assessment of the justification and effectiveness of future CON regulation will require a reexamination of the determinants of hospital utilization and capacity.

This paper analyzes the capacity investment decision of hospitals and the relationship between capacity and utilization. The goal is to examine a general demand-pull model of hospital cost inflation where hospitals respond to increases in demand by expanding capacity and increasing quality. The continued growth of public and private insurance, for example, may encourage hospitals to further increase the quality of care they provide. Spiraling costs may result if these increases in quality lead to additional increases in demand. The paper focuses on the effects of non-profit, for-profit, and government ownership in an effort to determine whether and how the demand-pull model of inflation is affected by organizational incentives. The organization of the paper is as follows.

Section II discusses the theory of property rights as it might apply to the hospital industry. The mechanism by which ownership may be expected to affect firm behavior is explicitly specified.



Public and private, non-profit hospitals are assumed to be subject to profit constraints that private, for-profit hospitals do not need to satisfy. The theoretical model studies the behavior of a monopoly hospital and is consistent with the general demand-pull model of cost inflation first formulated by Martin Feldstein (1971, 1977). Cost inflation refers to a rise in the total cost of hospital care. Two potential sources of inflation are identified, but the discussion is left for Sections III and IV.

Section III presents an analysis of the first source of hospital cost inflation. Inflation may result if hospitals overinvest in bed capacity. This is the "supply" effect, where hospitals provide more beds than necessary to satisfy demand efficiently. The major theoretical results from this section argue that profit-constrained firms will overinvest in capacity relative to profit-unconstrained firms and that profit-constrained firms will respond to increases in revenue with relatively larger increases in capacity, but not price.

Section IV discusses the second source of inflation. Roemer's Law suggests that total hospital costs may rise if an increase in hospital capacity leads to further increases demand. In markets characterized by random demand and uncertain availability, hospital bed capacity becomes an important quality attribute of hospital care. An expansion of capacity, which corresponds to an increase in quality, may therefore increase demand. This may be termed a "consumption" effect, which can be measured by the increase in the number of patients served and the average length of hospitalization.

The empirical work in this paper can be summarized simply. Aggregate time-series and state cross-section data on U.S. hospitals confirm the theoretical implications described in Section III. On average, public and private, non-profit hospitals have larger bed capacity than for-profit firms. Furthermore, it is apparent that hospitals in these two ownership categories have responded to past increases in demand with larger increases in capacity. The empirical analysis also confirms Roemer's Law, which appears to vary by ownership. The data suggest that a given percentage increase in bed capacity leads to a greater increase in utilization in public and private, non-profit hospitals.

Section V concludes the paper with an agenda for future work. In sum, the results suggest that organizational incentives in public and private, non-profit hospitals may lead to significant demand-pull inflation. The total cost of hospital care may rise faster in these two ownership categories for two reasons. First, a given increase in demand leads to the higher costs that are associated with a greater investment in bed capacity. Second, a given expansion in capacity leads to the higher costs that are associated with a larger increase in hospital utilization.



## SECTION II. OWNERSHIP AND CONTROL IN THE HOSPITAL INDUSTRY

The theory of property rights comprises the dominant positive model of the effect of ownership on organizational behavior. Profit maximization in a competitive marketplace is considered to be efficient, and this theory argues that when property rights are attenuated, owners of the firm have fewer incentives to reduce managerial shirking or to minimize costs. In general, property rights are attenuated when there exists separation between ownership and control, that is, when the managers or decisionmakers of the firm are not also the residual claimants or owners of the firm (Alchian and Demsetz, 1972; Jensen and Meckling, 1976).

Property rights are assumed to be the least attenuated in private, for-profit firms. Even if there is separation of ownership and control, owners of these firms have the incentive to monitor managerial behavior and firm costs since they have claims to all firm profits. Furthermore, since ownership rights to these firms may be bought and sold, an efficient takeover market yields profits to investors who bring about improvements in efficiency. Although Grossman and Hart (1980) have shown that corporate takeovers may not be sufficient to deter discretionary managerial behavior in private firms, Fama and Jensen (1983a,b) and advocates of the theory of property rights argue that the existence of a stock market, takeover market, or expert board of directors serves to eliminate or deter non-profit maximizing behavior in private firms.

Property rights are presumably the most attenuated in the public or government-run firms, where ownership rights belong to the community and therefore cannot be traded. This "non-transferability" of ownership leads clearly to a separation of ownership and control with no mechanism like a takeover market to enforce efficient managerial behavior. Two reasons commonly given to explain discretionary behavior in public organizations include bureaucratic objectives and "capture" by organized interest groups.

The issue of property rights in private, non-profit firms is more difficult to assess. Non-profit firms are similar to government-owned firms in that these organizations also have no residual claimants. The principal characteristic that distinguishes non-profit firms from other organizational forms is a legal constraint that prohibits individuals who exercise control over the firm -- owners, managers, members, or directors -- from receiving any of the firm's residual earnings (Hansmann, 1980). Since non-profit firms have no stock or other forms of ownership that give their owners both control over managerial decisions and a share of firm profits, the opportunity for managerial discretion exists. Furthermore, if these organizations receive donations or revenues not contingent on specific output, managers of non-profit firms may have additional opportunity to engage in discretionary activity.

As with other private firms, however, market mechanisms may serve to reduce or eliminate

managerial inefficiency in non-profit organizations. For example, non-profit firms may be acquired by proprietary corporations. Furthermore, donors have interests in seeing their donations used effectively. If donors are few in number and able to organize as members of the governing board, complete monitoring of managers may result.

In sum, the theory of property rights suggests that public firms are less efficient than private firms. Private, for-profit firms are presumably the most efficient, with private, non-profit firms falling somewhere inbetween.

These results have also been shown more formally in a variety of contexts. One general formulation analyzes the behavior of the individual manager. Managers are assumed to maximize their utility, which is some function of income and non-pecuniary benefits. These non-pecuniary benefits may include quantity of output, quality of output, perquisites, or preferences for some specialized technology or input to production. Managers set the price to maximize profits, and they spend these profits to achieve some combination of quantity, quality, and other non-pecuniary benefits. In a pure profit-maximizing firm where the manager is also a residual claimant of the firm, an increase in any of the non-pecuniary benefits is traded off with a reduction in firm profits. However, when property rights are attenuated and the manager's income is some fraction of firm profits, the increase in non-pecuniary benefits is traded off with the reduction in income received by the manager. Since the manager's income is some fraction of firm profits, attenuation effectively lowers the price of non-pecuniary benefits and the manager optimally consumes more of these benefits. The general result from this literature is that attenuation of property rights leads to an inefficiency in the manager's choice of inputs.

Many behavioral models of the hospital follow this logic. M.L. Lee (1971), for example, considers the utility-maximizing hospital administrator who engages in "conspicuous consumption" to maximize his or her facility's prestige. Prestige is technologically determined by the quality and quantity of the hospital inputs used in production. Newhouse (1970) describes a similar model where the hospital administrator seeks to maximize some function of both quality and quantity.

Discretionary managerial behavior may be conceptualized as a constraint on firm profits. For example, managers who care about total revenues (and not net profit) may be thought of as maximizing sales subject to a minimum profit constraint. Here, firms maximize profits in the short run and invest in additional capacity, technology, or facilities in a way that generates the largest possible increase in output (Baumol, 1959). Alternatively, Alchian and Kessel (1962) model the regulated monopoly as subject to a maximum profit constraint. Here, firms maximize profit and once the maximum allowable rate of return is reached, higher potential profits are ruled out and traded off for other activities that yield direct managerial utility.

This analysis begins by conceptualizing the effect of ownership structure as a constraint on



firm profits. The theoretical model formulated below is simply a reinterpretation of the capacity choice problem specified in Averch and Johnson's (1962) study of firm behavior under rate of return regulation. The theory that follows is not new and is restated to make explicit the behavioral differences we expect to observe between non-profit, for-profit, and public firms.

#### A. Ownership and the Supply of Hospital Services

We begin by studying the pure, profit-maximizing monopoly firm. In the simple behavioral model described here, the hospital produces only one output, which is measured by the number of hospital inpatient days. Only two inputs, labor and hospital beds, are used. The actions of insurers, physicians, and regulators are assumed exogenous. With these caveats, the expression for firm profits may be written as follows:

$$\Pi = P(Z)Z - rB - wL$$

*Handwritten:*  
 $\frac{d\Pi}{dq}$

where

- $\Pi$  = total firm profits
- $P(Z)$  = inverse demand function
- $Z$  = number of inpatient days
- $B$  = hospital bed capacity
- $L$  = labor input
- $r$  = unit cost of capacity
- $w$  = unit cost of labor.

All relevant functions are twice differentiable and all second-order conditions are assumed to be satisfied. The technology may be described by the production function

$$Z = Z(B,L)$$

where

$$Z_B > 0, Z_L > 0, \text{ and } Z(B,0) = Z(0,L) = 0.$$

Subscripts denote partial derivatives.

The firm's decisions are affected by ownership structure in only one way: ownership structure affects firm behavior through a constraint on the maximum allowable rate of return on capital. In my formulation, capital is equivalent to capacity. In private, for-profit firms, owners have profit

maximization as their only goal, and the maximum allowable rate of return is therefore unconstrained. Furthermore, various market mechanisms are in place to limit or eliminate managerial discretion. As a result, managers act to maximize profits.

In contrast, a constraint on the maximum allowable rate of return may be binding in both public and private, non-profit firms. I assume this to be the case always. Social and political forces may dictate some maximum rate of return on capital. For example, government budget cuts may be more likely to hit public entities that make profits above some predetermined level. In the case of the private, non-profit firm, excess profits may lead to cuts in government grants, donations, and penalties enforced by the Internal Revenue Service. Thus, higher profit levels beyond some maximum rate of return are effectively ruled out. Furthermore, since the attenuation in property rights gives managers the opportunity to engage in discretionary spending, these higher potential profits are reinvested in the firm according to the discretionary preferences of the managers.

In the analytic model specified below, hospital managers are assumed to have discretionary preferences for investment in bed capacity. One may interpret this as a preference for increased quantity or quality of care (since an increase in capacity reduces waiting time for patients) and/or prestige (an increase in capacity may increase a manager's reputation or status).

To summarize, various social and political forces determine a maximum rate of return that managers of public and non-profit firms must satisfy. The profit constraint is binding for these firms. Beyond this maximum rate of return, higher profits are ruled out and are traded off for discretionary activities, such as additional investment in bed capacity. All of this may be described more formally by the profit constraint below:

$$(1/B)(PZ - wL - rB) \leq v$$

where  $v$  is the maximum allowable rate of return above the cost of capital. This simplifies to the following:

$$PZ - wL \leq sB \tag{1}$$

where  $s = r + v =$  the maximum allowable rate of return on capital.

By defining the maximum rate of return as net revenue over capacity, we implicitly assume that managers have discretionary preferences for investments in bed capacity. In the for-profit firm, where the profit constraint is not binding, property rights insures that managers invest in capacity only to the extent that profits are maximized. In contrast, managers of public and



non-profit hospitals have the greatest opportunity to invest in bed capacity to their discretion. Although managers of public and non-profit hospitals also maximize profits, the attenuation of property rights allows managers to invest in bed capacity when profits surpass some predetermined level of profit.

## B. Hospital Cost Inflation

The model described above is analogous in behavior to the model of hospital cost inflation formulated by Martin Feldstein (1971, 1977). Feldstein argues that an increased demand for hospital care (caused by the growth of public and private insurance, for example) will lead hospitals to increase the quality of hospital care. More specifically, an increase in demand leads to a rise in hospital costs because of the non-profit nature of the hospital. In non-profit hospitals, an increase in revenue is used to provide a more expensive "quality" or style of care. Moreover, this increase in quality causes demand to increase even further. Feldstein points to this two-way relation between demand and quality as the fundamental reason why hospital costs have soared.

Analytically, Feldstein models the utility maximizing manager of a non-profit hospital as having preferences over quality and hospital bed capacity. Managers choose the inputs to production to maximize quality. Although quality is specified as a function of the inputs to production, quality is not defined or made operational. In the model above, quality is defined by hospital bed capacity. An increase in capacity reduces waiting time in the hospital.

Feldstein argues that demand-pull inflation is a phenomenon due to the non-profit nature of the hospital industry. It is not clear, however, why Feldstein's argument is not also applicable to the for-profit hospital. Do profit-maximizing managers of for-profit hospitals not have preferences over quality and bed capacity? Without assuming differences between non-profit, for-profit, and government hospital managers regarding preferences over quality or capacity, the above model will allow us examine how the non-profit nature of the hospital industry can lead to a spiraling rise in hospital costs.

In my analysis of the demand-pull model of inflation, I focus on the capacity choice problem. In doing so, I characterize the rise in inflation as the result of two effects. First, inflation may result if hospitals overinvest in bed capacity. This is the "supply" effect, where hospitals provide more beds than necessary to satisfy demand efficiently. Second, as Roemer's Law might suggest, total hospital costs may rise if an increase in hospital capacity leads to further increases demand. In markets characterized by random demand and uncertain availability, hospital bed capacity becomes an important quality attribute of hospital care. An expansion of capacity thus corresponds to an increase in quality. This may be termed a "consumption" effect, which may be measured by the increase in the

number of patients served and the quality of treatment provided.

The balance of this paper attempts to quantify the "supply" effect and "consumption" effect as they relate to the ownership structure of the hospital. Overall, which of the two effects is more important in determining the rise of hospital costs? Do organizational incentives in public and private, non-profit hospitals lead to significant demand-pull inflation?

### SECTION III. THE CAPACITY CHOICE PROBLEM IN HOSPITALS

#### A. The Demand for Hospital Services

Researchers have long recognized that the demand for hospital care is random. Chiswick's (1976) study of utilization and hospital occupancy rates, for example, explicitly assumes a stochastic demand process. Queuing theory has also been widely used in hospital planning, and hospital bed planning is a textbook example. Rosenthal (1964), in his study of the relationship between hospital bed supply and utilization, applies queuing theory directly. Joskow (1980) and Mulligan (1985) also estimate simple queuing models in their studies of the determinants of hospital bed capacity.

Economists have also recognized the value of capacity to consumers when demand is random and the availability of a product uncertain. De Vany (1975) and De Vany and Saving (1977) emphasize the point that firm capacity affects both the quantity and quality of output, since capacity serves to reduce waiting time and planning costs for consumers. Consumers dislike the time spent waiting for admission or the delay in treatment that may occur in an overcrowded hospital. In short, availability is important in markets where demand is random. These ideas have been extended to competitive situations where prices are either inflexible (Carlton, 1978) or regulated (Douglas and Miller, 1974a,b).

In markets where demand is random and availability important, capacity will be valuable to consumers. Thus, although the need for hospital care may occur randomly according to some specified stochastic process, the effective demand facing the firm is not random. Instead, demand is a function of capacity and waiting time.

We may begin by specifying some function  $Z_t^m = Z^m(X_t)$ , which determines the maximum number of potential patients and potential hospital inpatient days in a given population at some time  $t$ .  $X_t$  is a vector of variables that may include the availability of physicians in the population, personal income, the extent of insurance coverage in the population, the relative price of hospital care, current health status, and the distance one must travel from home to hospital.

The stochastic aspect of demand is introduced by assuming that only a certain fraction  $e$  of the maximum number of patients will desire hospitalization. The relevant output, denoted by the variable  $Z_t$ , is the number of inpatient days of care desired in a given population. We may think of  $Z_t$  as being determined by the following:  $Z_t = eZ_t^m$ , where  $e$  is a random or stochastic term between 0 and 1.

The effective demand faced by the firm, however, is not random. Since availability is important



to consumers, the actual number of inpatient days of hospitalization provided by a given hospital will depend on that hospital's level of capacity. Dropping the time subscripts, we can write the inverse demand function as follows:

$$P = P(Z,W) \tag{2}$$

where  $P$  = price of one inpatient day of hospital care  
 $Z$  = number of inpatient days of hospital care demanded  
 $W$  = waiting time or delay in treatment before and during service.

When prices fall, consumers purchase more hospital care and are willing to wait longer for treatment. Thus, I expect the following partial derivatives:

$$P_Z < 0, \text{ and } P_W < 0.$$

The stochastic demand process is also implicitly specified in the waiting time function. Following Douglas and Miller (1974b), the waiting time function may be generalized as follows:

$$W = W(B,u,Z) \tag{3}$$

where  $B$  = hospital bed capacity  
 $u$  = dispersion of demand  
 $Z$  = number of inpatient days of hospital care demanded.

I expect the following partial derivatives:

$$W_b < 0, W_u > 0, \text{ and } W_z > 0.$$

The expected waiting time is shorter in hospitals with more bed capacity. Expected waiting time is longer in hospitals subject to more demand uncertainty and higher patient loads. For simplicity, I will assume that  $u = u(Z)$ . After substituting (3) into (2), we can rewrite the inverse industry demand function as follows:

$$P = P(Z,B). \tag{4}$$



In sum, greater bed capacity serves to shift the effective demand curve to the right. An increase in capacity corresponds to an increase in quality by reducing congestion and the time spent waiting for treatment.

## B. The Supply of Hospital Services

A firm maximizing profits without constraints on its rate of return on capacity chooses levels of labor input and bed capacity to minimize costs. Given the inverse demand curve in equation (4), the expression for firm profits is as follows:

$$\Pi = P(Z,B)Z - rB - wL \quad (5)$$

where  $Z^* = Z(B,L)$ . Profit maximization implies the following first order conditions:

$$Z_b(P + ZP_z) + ZP_b = r \quad (6)$$

$$Z_l(P + ZP_z) = w \quad (7)$$

where subscripts denote partial derivatives. Interpretation of (6) is straightforward. Firms expand bed capacity to the point where the value of the marginal product of an additional bed equals the price of an additional bed. It is clear from (6) that the revenue received from consumers includes the price of available capacity. Combining (6) and (7) with some rearrangement yields the following:

$$Z_b/Z_l = r/w - ZP_b/w. \quad (8)$$

The efficient input mix is such that the ratio of marginal products is less than the ratio of factor prices. When availability is important to consumers, firms efficiently provide excess capacity. The greater the increase in price that consumers are willing to pay for additional capacity, the greater the capacity level that firms will provide.

A profit-constrained firm, however, maximizes profits subject to the constraint given by equation (1). The resulting first order conditions, including the profit constraint, are as follows:

$$(1-\mu)[Z_b(P + ZP_z) + ZP_b] = r - \mu s \quad (9)$$

$$(1-\mu)[Z_l(P + ZP_z)] = w - \mu w \quad (10)$$

$$PZ - wL = sB \quad (1)$$

where  $s = r + v$  = the maximum allowable rate of return on capacity,  
 $\mu$  is the Lagrange multiplier associated with the profit constraint.

Combining (9) and (10) and rearranging yields the following:

$$Z_b/Z_l = r/w - ZP_b/w - [\mu/(1-\mu)][(s-r)/w] \quad (11)$$

A comparison of (11) to (8) shows that the profit-constrained firm does not choose the input mix that minimizes costs. Although we cannot say that the capacity/labor ratio is larger in the profit-constrained firm than in the unconstrained profit-maximizing firm, we can say that for a given level of output, equation (11) implies that profit-constrained firms overinvest in capacity. This is the classic Averch-Johnson result, which is graphed in Figure 1. The empirical implication is clear: unconstrained private, for-profit firms will invest less in bed capacity than will their profit-constrained, public and non-profit counterparts.

Given the framework above, we can show that as the profit constraint becomes tighter, firms increase their investment in capacity. The proof, which may be found in Baumol and Klevorick (1970), rests on the assumption that  $r < s < r_f$  (where  $r_f$  is the unconstrained profit-maximizing rate of return) and the result that  $0 < \mu < 1$ . In other words, the maximum allowable rate of return must be a binding constraint in public and non-profit firms. The empirical implication of this result is that as the gap between the allowed rate of return and the cost of capital falls, a profit-constrained firm will increase its investment in capacity. According to the theory of property rights, we thus expect public hospitals to have the greatest investment in capacity.

### C. The Differential Effects of Ownership on Capacity Choice

We can solve for the profit-constrained firm's choice of bed capacity by solving the first order conditions given by equations (1), (9), and (10). Total differentiation of the profit constraint (1) yields

FIGURE 1. THE OVERINVESTMENT IN CAPACITY IN PROFIT-CONSTRAINED FIRMS

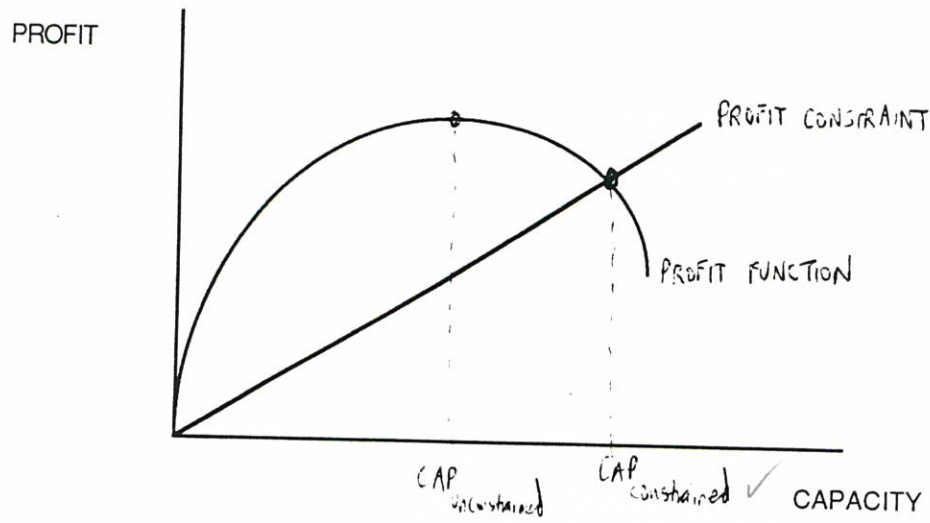
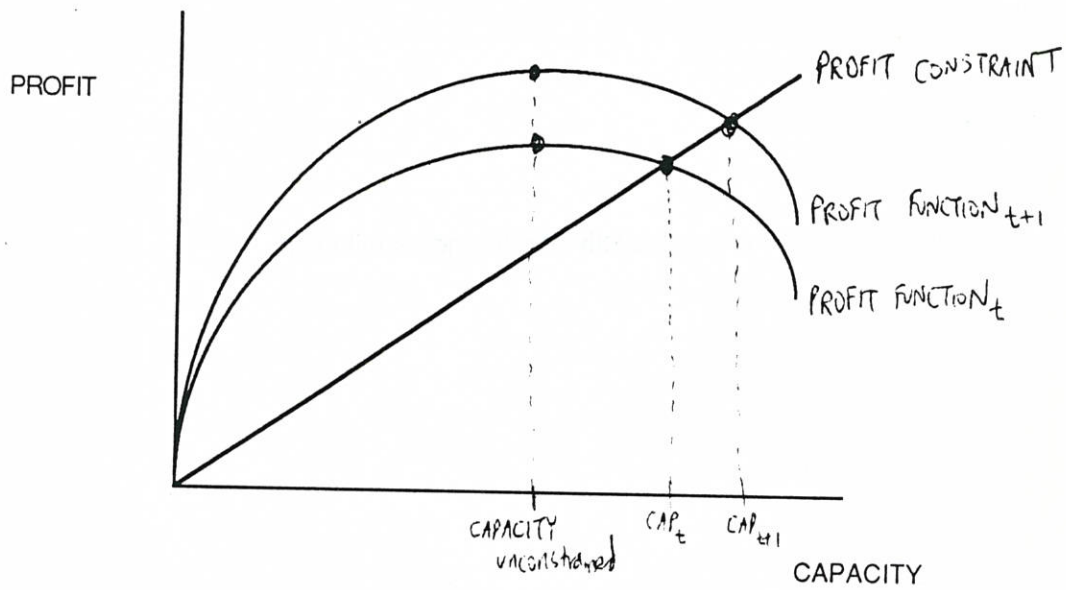


FIGURE 2. THE INVESTMENT IN CAPACITY AND CHANGES IN REVENUE



$$R_l dL + R_b dB - w dl = s dB + B ds$$

where

$$R = PZ = \text{firm revenue}$$

$$R_b = Z_b(P + ZP_z) + ZP_b.$$

Rearranging implies that

$$(R_l - w)dL + (R_b - s)dB = B ds.$$

Since equation (10) implies that  $R_l = w$ , we can solve for B as follows:

$$B = (R_b - s)(dB/ds).$$

Substituting for  $R_b$  gives the following:

$$B = [Z_b(P + ZP_z) + ZP_b - s](dB/ds).$$

We can rewrite  $(P + ZP_z)$  in terms of the price elasticity of demand as follows:

$$(P + ZP_z) = P[1 - 1/\Sigma]$$

where

$$\Sigma = -(dP/P)/(dZ/Z).$$

Substituting leads to our final expression:

$$B = (s - PZ_b [1 - 1/\Sigma] - ZP_b)(-dB/ds). \quad (12)$$

We see from (12) that hospital bed capacity depends on the price of output, the technological factors that determine the marginal product of an additional bed, the price elasticity of demand, the level of demand, the price consumers are willing to pay for availability, and the maximum allowable rate of return. Clearly, changes in demand are expected to affect the level of capacity differentially across ownership categories.



We can also formalize Feldstein's intuition that non-profit firms respond to increases in revenue by increasing quality. Differentiating the constraint (1) implies the following:

$$dR - wdL = sdB.$$

Rearranging implies that

$$dB/dR = [1/s][1 - wdL/dR].$$

When revenues increase, profit-constrained firms respond by larger increases in capacity, holding labor inputs fixed. On the other hand, when the constraint loosens,  $s$  increases and  $dB/dR$  falls. Figure 2 graphically illustrates this result.

#### D. Ownership and Cost Inflation

The above result suggests that profit-constrained firms respond to increases in demand by larger increases in capacity. How this affects hospital prices can now be made explicit. Consider the unconstrained, profit-maximizing firm's optimal condition for capacity choice. It is straightforward to rewrite (6) as a price markup over the marginal cost of capital:

$$[P - r/Z_b]/P = 1/\Sigma - (\Sigma_{PB})(\Sigma_{BZ})$$

where

$\Sigma$  = the elasticity of demand with respect to price

$\Sigma_{PB}$  = the elasticity of price with respect to capacity

$\Sigma_{BZ}$  = the elasticity of capacity with respect to demand.

This is analogous to the standard monopoly result, where the price markup is inversely related to the price elasticity of demand. The result here is that the price markup is higher when the expansion in capacity due to an increase in demand is smaller, that is, when  $\Sigma_{BZ}$  is small. The importance of this result is as follows: the unconstrained profit-maximizing firm is thus expected to respond to increases in demand by larger increases in price rather than capacity. Such a response has implications to the theory of demand-pull cost inflation in that a response to increase price rather than capacity will not lead to further increases in demand in the future.

## E. An Empirical Study of the Determinants of Bed Capacity

The empirical work presented in this section attempts to determine the effect of ownership structure on hospital bed capacity. From above, the first theoretical result suggests that profit-constrained firms make larger investments in capacity. A second result suggests that profit-constrained firms respond to increases in revenue with greater increases in capacity. The analysis below attempts to validate these implications empirically.

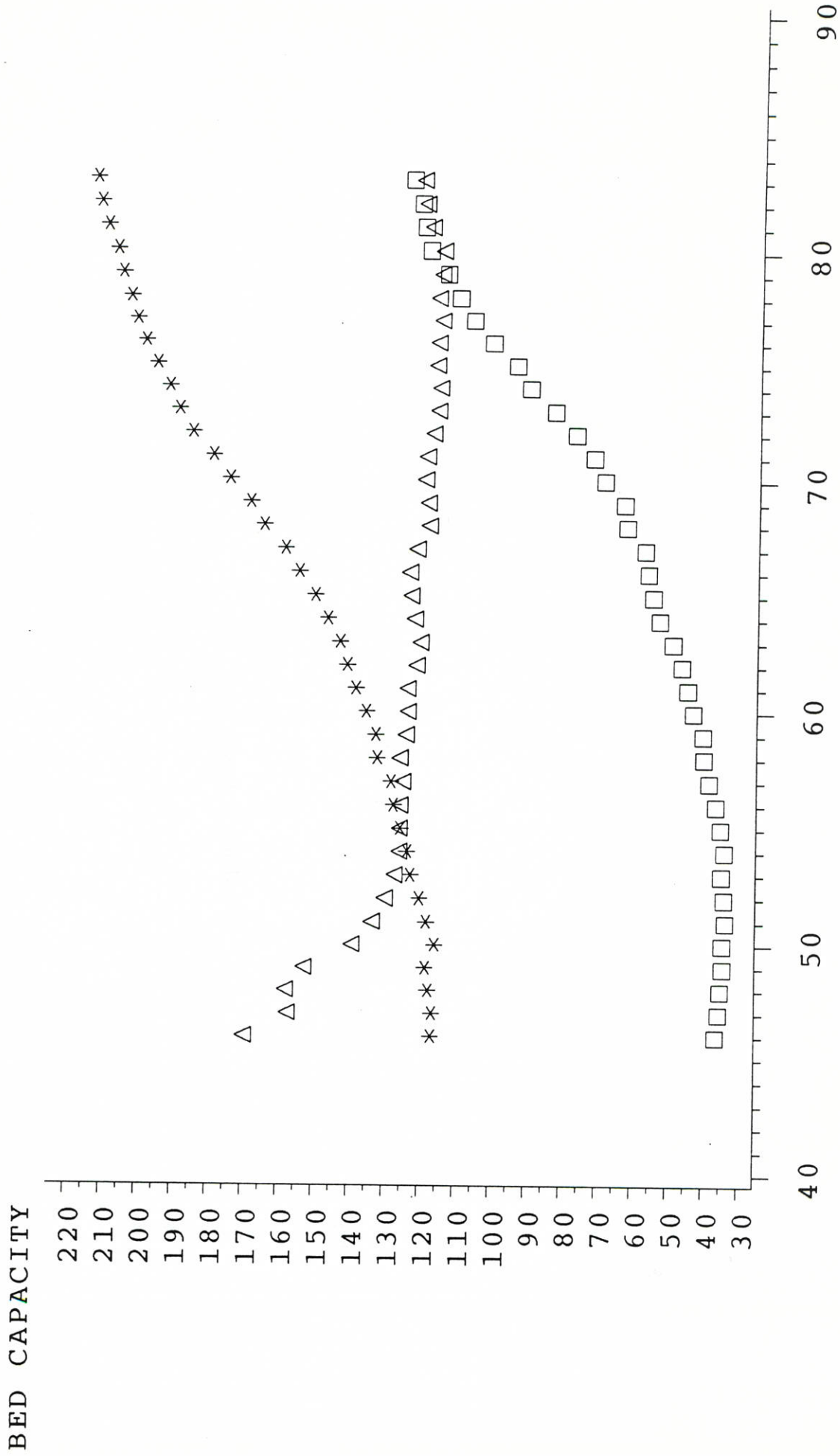
The data on hospital capacity used in this study may be found in various issues of Hospital Statistics, which is published annually by the American Hospital Association. Data on short-term general and other special hospitals may be classified into three categories on the basis of ownership: non-profit, for-profit, and government (state and local). Hospitals are classified according to their average length of hospitalization, and a short-term hospital is one in which the average length of stay is less than 30 days. Not included in my data are long-term general hospitals, federal hospitals, psychiatric hospitals, hospitals for tuberculosis and other respiratory diseases, and institutions for the mentally retarded and the chemically dependent.

I constructed one time-series dataset and one cross-section dataset for this study from the data sources described below. The specific variables I use are described in further detail in the tables and figures presented in this section.

1. The time-series consists of U.S. annual aggregate data for each hospital ownership category from 1946 to 1983. Annual demographic, income, insurance, and government expenditure data were collected from various issues of the Statistical Abstract of the United States, the 1990 Economic Report of the President, and the Historical Statistics of the United States: Colonial Times to 1970.
2. The cross-section consists of U.S. state aggregate data for each hospital ownership category in 1982. State demographic, income, regulatory, insurance, and government expenditure data were collected from the Statistical Abstract of the United States, the State and Metropolitan Area Data Book, 1986, the Source Book of Health Insurance Data, the Health Care Financing Review, Insurance Facts: Property/Casualty Fact Book, the Hill-Burton Project Register, and Status Report on State Certificate of Need Programs.

On average, for-profit hospitals are smaller in hospital bed capacity than their non-profit counterparts. The graph in Figure 3 shows that both types of private hospitals, non-profit and for-profit, have been increasing in scale over time, with the difference in size between the two ownership categories remaining fairly constant. On the other hand, the scale of government hospitals

# OWNERSHIP AND AVG. BED CAPACITY



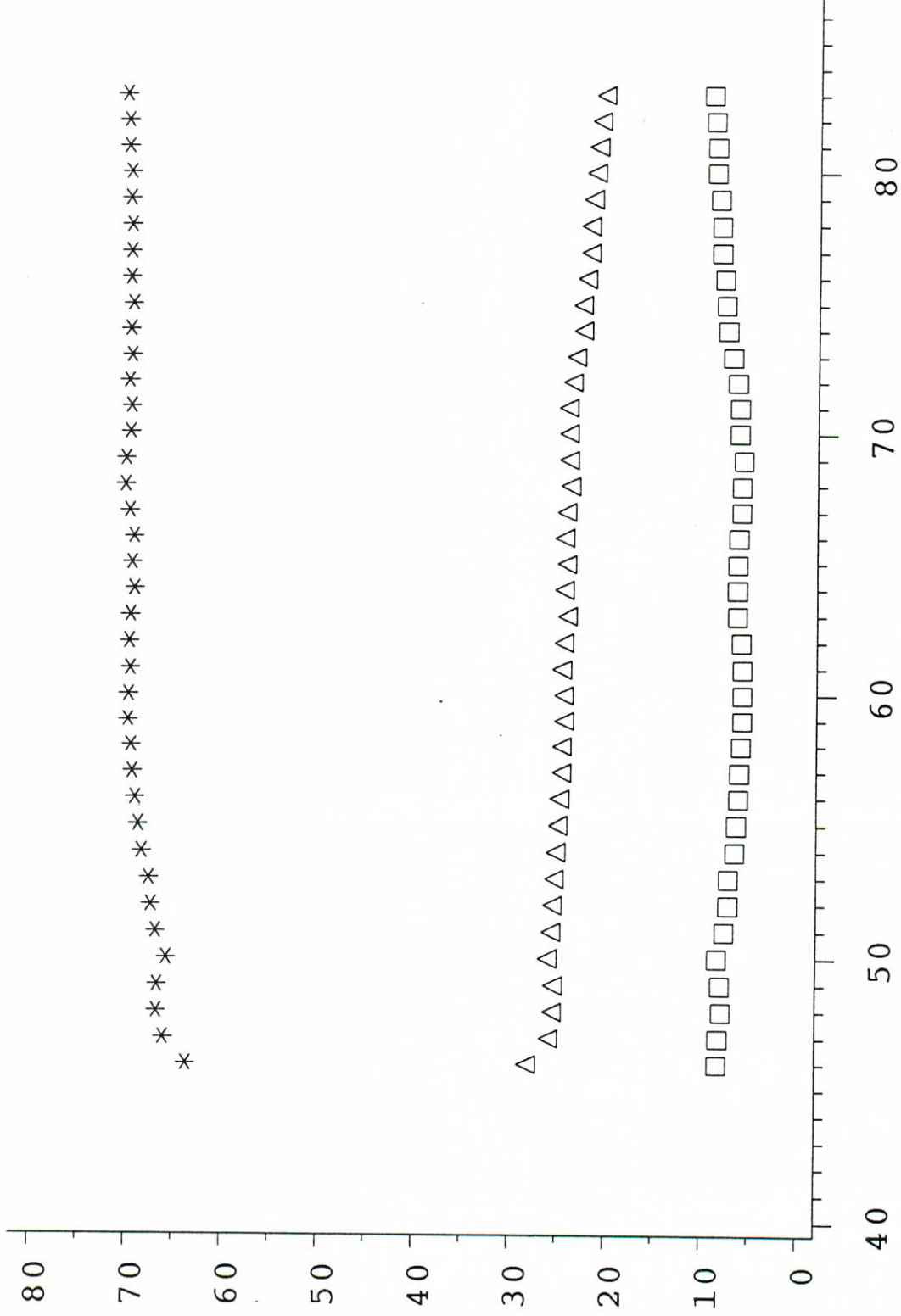
YEAR: 1946-1983

STAR: NON-PROFITS SQUARE: FOR-PROFITS TRIANGLE: GOVT.  
 DATA: U.S. ANNUAL AGGREGATE DATA



# OWNERSHIP AND MARKET SHARE OF CAPAC

MAR  KET SHARE



YEAR: 1946-1983

STAR: NON-PROFITS SQUARE: FOR-PROFITS TRIANGLE: GOVT.  
 DATA: U.S. ANNUAL AGGREGATE DATA

TABLE 1: OWNERSHIP AND CAPACITY UTILIZATION: 1982 DATA

Variable	Non-Profit	For-Profit	Government	
			Local Govt	State Govt
NUMBER OF HOSPITALS:	3261	717	1617	121
6-24 Beds	82	33	117	10
25-49 Beds	367	107	469	27
50-99 Beds	644	206	541	16
100-199 Beds	817	240	274	18
200-299 Beds	524	96	97	12
300-399 Beds	340	22	44	12
400-499 Beds	222	12	29	9
500 or more	265	1	46	17
OCCUPANCY RATE (%):	77.8	65.8	70.2	73.0
6-24 Beds	45.3	46.8	44.5	32.0
25-49 Beds	52.8	53.9	50.0	35.2
50-99 Beds	65.8 ✓	59.5 ✓	63.3	47.6
100-199 Beds	72.6 ✓	63.7 ✓	71.7	63.1
200-299 Beds	78.5 ✓	71.0 ✓	74.8	74.4
300-399 Beds	80.2	75.6	74.5	80.4
400-499 Beds	81.2	72.3	77.2	76.9
500 or more	82.6	68.7	80.5	76.7

Note: All figures are based on U.S. aggregate statistics of all non-federal short-term hospitals.  
 Source: Table 2a, 1983 Hospital Statistics, American Hospital Association.

has been falling slowly over time. This is a little misleading, though, since the capacity of government hospitals appears to vary by location: large government hospitals are typically located in metropolitan areas and small government hospitals tend to be located in more rural areas. In aggregate, however, the percentage distribution of total beds supplied by ownership category has remained fairly constant, and this is shown in Figure 4.

Table 1 gives the distribution of hospitals by ownership and bed capacity. To a large extent, the difference in scale between the non-profit and for-profit firms may be explained by the large government subsidies for hospital construction that were made available through the Hill-Burton Act of 1946. Only non-profit and government hospitals were eligible for these funds. Empirically, the availability of these funds should be considered as greatly reducing the cost of capacity to non-profit and for-profit hospitals.

#### F. Estimation of a Dynamic Model of Capacity Choice

The choice of capacity is not a static decision, nor can all adjustments be made instantaneously. In the short run, firms may accommodate increases in demand by working overtime. We might expect changes in capacity to occur only in the long run. Such a delay in reaction suggests inclusion of lagged variables. The approach taken here utilizes a distributed lag relationship, which has often been applied in the analysis of the demand for consumer durables. One reason for the lagged response in capacity investment to changes in demand is the time required for regulatory approval or the construction that may be involved in the opening of a new wing of the building. Institutional factors may make this lagged response vary across ownership categories. Bureaucratic rigidities, for example, may lead public hospitals to respond more slowly to changes in demand.

A common dynamic model is the partial adjustment model, which uses a Koyck distributed lag. According to this model, the change in bed capacity is proportional to the gap between current desired capacity and the past actual level. More formally, the desired level of bed capacity at time  $t$ , denoted by  $B_t^*$ , may be written as a function of current demand factors,  $X_t$ , as follows:

$$B_t^* = \beta_0 + \beta_1 X_t. \quad (13)$$

However, we may not expect actual capacity to adjust completely in time  $t$  to changes in demand at time  $t$ . Instead, the annual change in capacity may be represented as follows:

$$B_t - B_{t-1} = (1-\theta)(B_t^* - B_{t-1}) + u_t \quad (14)$$



where  $0 \leq \emptyset \leq 1$ .

A stochastic disturbance term,  $u_t$ , is included, as well. We can rewrite (14) to show that current bed capacity is a weighted average of the current desired level and the past actual level.

$$B_t = (1-\emptyset)(B_t^*) + \emptyset(B_{t-1}) + u_t \quad (15)$$

Substituting (13) into (15) yields our final expression for the level of hospital capacity observed at time t:

$$B_t = (1-\emptyset)\beta_0 + [(1-\emptyset)\beta_1]X_t + (\emptyset)B_{t-1} + u_t \quad (16)$$

If we assume that the error term  $u_t$  is normally distributed, the OLS estimators are efficient. This provides justification for the use of OLS in regression analysis with lagged variables.

The parameter  $\emptyset$  is interpreted as the adjustment coefficient, representing the extent to which current capacity reflects past rather than the current desired level of capacity. A high value of  $\emptyset$  suggests that capacity adjustment is slow. A small value of  $\emptyset$  implies that hospitals are able to adjust capacity quickly in response to current demand shocks.

If we assume that the capacity investment function has constant elasticity, then (16) becomes the following:

$$\text{Ln}B_t = (1-\emptyset)(\text{Ln}\beta_0) + [(1-\emptyset)\beta_1]\text{Ln}X_t + \emptyset(\text{Ln}B_{t-1}) + u_t \quad (17)$$

where Ln denotes a logarithmic transformation. Estimation of (17) yields the short-run elasticity of capacity with respect to demand:  $[(1-\emptyset)\beta_1]$ ; the long-run elasticity of capacity with respect to demand:  $[\beta_1]$ ; and the estimated adjustment parameter:  $[\emptyset]$ .

One drawback of the partial adjustment model is that the speed of capacity adjustment is assumed to be the same with respect to changes in all demand factors and other explanatory variables.

I estimated the hospital bed capacity equation described by (17) separately for each ownership category using U.S. aggregate time-series data. The vector  $X_t$  of demand factors included the following variables: 1) the market share of the ownership category; 2) the number of hospitals per population

as a proxy for the distance patients must travel for hospital care; 3) the physician/population ratio as a proxy for available physician services; 4) real disposable personal income per capita as a proxy for the value of time and the importance of availability to patients; 5) the relative price of medical care; 6) the percent of all health care expenditures covered by private health insurance; 7) interest rates as a proxy for the cost of debt capital; 8) the Standard and Poor 500 Index as a proxy for the cost of equity capital; and 9) the amount of government expenditures on hospital construction as measure of the various government benefits accorded to government and non-profit firms.

The results of the lagged variable model, which are shown in Table 2, confirm that for-profit hospitals are relatively smaller in capacity than both public and non-profit firms. The constant term is largest for the government sample and smallest for the for-profit sample, which is consistent with the theoretical results hypothesized above.

The most striking empirical finding is the apparent difference in the factors that determine capacity. Contemporaneous increases in physician availability and income lead to significant increases in capacity in for-profit hospitals, but not in public or non-profit hospitals. Increases in past utilization lead to increases in capacity in public and non-profit hospitals, but not for-profit hospitals. A percentage point increase in past demand leads to a 0.41 percent increase in capacity in non-profit hospitals and a 0.18 percent increase in public hospitals. Furthermore, the coefficient of the lagged bed capacity variable suggests that capacity adjustments are made with greater speed in the public and non-profit firms. In sum, the data generally support the second theoretical result, as well: the public and non-profit hospitals adjust capacity with the greatest speed, and they do so in response to past increases in demand.

Table 3 gives the estimated short-run and long-run elasticities of capacity with respect to various demand factors. The long-run elasticity of capacity with respect to past utilization is 0.61 in non-profit hospitals and 0.25 in public hospitals, but -0.65 in for-profit hospitals. In contrast, capacity expansion in for-profit hospitals may be largely explained by contemporaneous demand shocks. The response to changes in physician availability and income is insignificant in public and non-profit hospitals; for for-profit hospitals, the elasticity of capacity with respect to physician availability and income is 1.81 and 1.19, respectively.

#### G. Controlling for the Effects of Hospital Casemix

It is possible that systematic differences in hospital casemix may affect the above results. It has been argued that for-profit hospitals prefer to locate in areas where patients are typically in better health. It has also been said that for-profit hospitals "cream-skim" patients, sending the more severely ill and more costly patients to the public and non-profit hospitals. This hypothesis



TABLE 2: BED CAPACITY REGRESSION PARAMETER ESTIMATES  
1949-1983 U.S. AGGREGATE TIME SERIES DATA

(Dependent Variable:  $\text{LnBEDI}_{i,t}$ ; Standard Errors in Parentheses)

PARAMETERS	Non-Profit Sample	For-Profit Sample	Government Sample
$\text{CONSTANT}_{i,t}$	0.85 (1.17)	-2.66 (1.88)	0.99 (0.49)
$\text{LnHOSPSHR}_{i,t}$	-0.55 (0.23)	-0.14 (0.13)	-0.33 (0.11)
$\text{LnHOSPPOP}_t$	-0.37 (0.12)	-0.08 (0.27)	-0.54 (0.13)
$\text{LnBEDI}_{i,t-1}$	0.33 (0.12)	0.69 (0.12)	0.27 (0.11)
$\text{LnDAY}_{i,t-1}$	0.41 (0.08)	-0.20 (0.10)	0.18 (0.07)
$\text{LnDOC}_t$	-0.04 (0.04)	0.56 (0.18)	0.03 (0.07)
$\text{LnINC}_t$	0.18 (0.08)	0.37 (0.16)	0.04 (0.07)
$\text{LnRPRICE}_t$	-0.15 (0.09)	-0.36 (0.21)	0.08 (0.09)
$\text{PINS}_t$	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)
$\text{LnINT}_t$	-0.01 (0.01)	-0.06 (0.03)	0.01 (0.01)
$\text{LnGTCON}_t$	-0.01 (0.01)	0.04 (0.04)	0.00 (0.02)
$\text{LnSP500}_t$	0.00 (0.01)	-0.03 (0.03)	-0.00 (0.01)
DW	2.46	2.16	1.90
R <sup>2</sup>	1.00	0.99	0.98
Adj. R <sup>2</sup>	1.00	0.99	0.98

VARIABLE DEFINITIONS (All variables are calculated for a given year t):

- $\text{LnBEDI}_{i,t}$  = Log of the average hospital bed capacity in the *i*th ownership category
- $\text{LnHOSPSHR}_{i,t}$  = Log of the market share of hospitals of the *i*th ownership category
- $\text{LnHOSPPOP}_t$  = Log of the total number of U.S. hospitals per total U.S. population
- $\text{LnDAY}_{i,t}$  = Log of the number of inpatient days for *i*th ownership category per total U.S. population
- $\text{LnDOC}_t$  = Log of the number of physicians per 100,000 resident population
- $\text{LnINC}_t$  = Log of real disposable personal income per capita (in constant 1982 dollars)
- $\text{LnRPRICE}_t$  = Log of the ratio of the Medical Care Consumer Price Index to the Consumer Price Index
- $\text{PINS}_t$  = Percent of all private consumer expenditures on health care covered by private insurance.
- $\text{LnINT}_t$  = Log of the prime interest rate charged by banks
- $\text{LnGTCON}_t$  = Log of public expenditures spent on medical facilities construction (in \$millions)
- $\text{LnSP500}_t$  = Log of the Standard and Poor's Composite Index of 500 Stocks



TABLE 3: ESTIMATES OF CAPACITY ADJUSTMENT IN HOSPITALS  
1949-1983 U.S. AGGREGATE TIME SERIES DATA

A. Estimated Capacity Adjustment Parameter

PARAMETER	Non-Profit Sample	For-Profit Sample	Government Sample
Adjustment Factor	0.33	0.69	0.27

NOTE: The adjustment parameter measures the extent to which current capacity reflects past rather than desired levels of capacity.

B. Estimated Short Run Elasticities of Bed Capacity ( $\text{LnBED}_{i,t}$ ) with respect to Demand Shifters

DEMAND FACTORS	Non-Profit Sample	For-Profit Sample	Government Sample
$\text{LnDAY}_{i,t-1}$	0.41	-0.20	0.18
$\text{LnDOC}_t$	-0.04	0.56	0.03
$\text{LnINC}_t$	0.18	0.37	0.04
$\text{PINS}_t$	0.00	0.00	-0.00

B. Estimated Long Run Elasticities of Bed Capacity ( $\text{LnBED}_{i,t}$ ) with respect to Demand Shifters

DEMAND FACTORS	Non-Profit Sample	For-Profit Sample	Government Sample
$\text{LnDAY}_{i,t-1}$	0.61	-0.65	0.25
$\text{LnDOC}_t$	-0.06	1.81	0.04
$\text{LnINC}_t$	0.26	1.19	0.05
$\text{PINS}_t$	0.00	0.00	-0.00

VARIABLE DEFINITIONS (All variables are calculated for a given year t):

$\text{LnBED}_{i,t}$  = Log of the average hospital bed capacity in the *i*th ownership category

$\text{LnDAY}_{i,t}$  = Log of the number of inpatient days for *i*th ownership category per total U.S. population

$\text{LnDOC}_t$  = Log of the number of physicians per 100,000 resident population

$\text{LnINC}_t$  = Log of real disposable personal income per capita (in constant 1982 dollars)

$\text{PINS}_t$  = Percent of all private consumer expenditures on health care covered by private insurance.

may explain why for-profit hospitals do not expand capacity in response to past utilization. If for-profit hospitals systematically treat patients who are less ill and therefore require fewer inpatient days of care, then we may not expect increases in past demand to lead to increases in the level of capacity.

In order to examine this possibility, the bed capacity equation was estimated using first differences. If we assume that location and hospital casemix effects are constant from year to year, then an analysis of first differences allows us to implicitly control for these effects. The results in Table 4 indicate that the previous results are fairly robust: non-profit hospitals apparently respond to past changes in demand, while for-profit firms respond to contemporaneous increases in demand. Government hospitals, however, are no longer as responsive to past increases in demand. Surprisingly, the percent insured remains an insignificant determinant of hospital capacity. Interestingly, the for-profit hospitals appear to be more responsive to contemporaneous changes in both demand and supply. In general, the results presented in the previous section still hold.

#### H. The Effects of Government Regulation

It may also be argued that hospitals are not free to choose their optimal level of capacity. This is relevant in more recent decades, with the increase in rate regulation and controls on hospital capacity. In an effort to see whether regulation has constrained hospitals' choice of capacity, I estimated the bed capacity equation separately for each ownership category with U.S. state aggregate cross-section data. The vector  $X_t$  of demand factors included the following variables: 1) market share of the ownership category; 2) the number of hospitals per population as a proxy of the distance patients must travel for hospital care; 3) the physician/population ratio as a proxy for available physician services; 4) real disposable personal income per capita as a proxy for the value of time and the importance of availability to patients; 5) the relative price of medical care; 6) the percent of all health care expenditures covered by private health insurance; 7) the presence of mandatory rate regulation; 8) the total dollar amount of Hill-Burton funding per facility; and 9) the percent dollar volume of Certificate-of-Need applications approved as a measure of regulatory stringency.

The cross-section results in Table 5 suggest that the effect of government regulation has not been large. Public hospitals appear to be helped the most by Hill-Burton funds. Certificate-of-Need regulation is insignificant, and the effects of mandatory rate regulation has encouraged the expansion of capacity in for-profit hospitals. The positive effect of increases in income on capacity expansion in the for-profit sector appears to be robust both cross-sectionally and over time. In sum, I will argue that the choice of capacity has not been constrained by government regulation.



TABLE 4: BED CAPACITY REGRESSION PARAMETER ESTIMATES  
1949-1983 U.S. AGGREGATE TIME SERIES DATA

(Dependent Variable:  $DBED_{i,t}$ ; Standard Errors in Parentheses)

PARAMETERS	Non-Profit Sample	For-Profit Sample	Government Sample
CONSTANT $_{i,t}$	0.01 (0.00)	0.02 (0.01)	-0.01 (0.01)
DHOSPSHR $_{i,t}$	-0.67 (0.28)	0.16 (0.18)	-0.47 (0.13)
DHOSPPOP $_t$	-0.61 (0.14)	-0.80 (0.33)	-0.72 (0.17)
DDAY $_{i,t-1}$	0.27 (0.11)	-0.16 (0.12)	0.01 (0.08)
DDOC $_t$	-0.04 (0.06)	0.62 (0.19)	0.15 (0.08)
DINC $_t$	0.14 (0.10)	0.56 (0.26)	0.18 (0.13)
DRPRICE $_t$	-0.10 (0.11)	-0.42 (0.32)	0.09 (0.14)
DPINS $_t$	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)
DINT $_t$	-0.00 (0.01)	-0.03 (0.03)	0.01 (0.02)
DGTCON $_t$	-0.01 (0.02)	0.11 (0.06)	0.03 (0.02)
DSP500 $_t$	-0.01 (0.01)	-0.07 (0.04)	-0.02 (0.02)
DW	2.23	1.84	2.04
R <sup>2</sup>	0.70	0.54	0.81
Adj. R <sup>2</sup>	0.56	0.34	0.73

VARIABLE DEFINITIONS (All variables are calculated as first differences between year t and year t-1 of the logarithms):

- DBED $_{i,t}$  = Change in average hospital bed capacity in the ith ownership category
- DHOSPSHR $_{i,t}$  = Change in market share of hospitals of the ith ownership category
- DHOSPPOP $_t$  = Change in the total number of U.S. hospitals per total U.S. population
- DDAY $_{i,t}$  = Change in inpatient days for ith ownership category per total U.S. population
- DDOC $_t$  = Change in the number of physicians per 100,000 resident population
- DINC $_t$  = Change in real disposable personal income per capita (in constant 1982 dollars)
- DRPRICE $_t$  = Change in ratio of the Medical Care Consumer Price Index to the Consumer Price Index
- DPINS $_t$  = Change in the percent of private consumer expenditures on health care covered by private insurance.
- DINT $_t$  = change in the prime interest rate charged by banks
- DGTCON $_t$  = Change in public expenditures spent on medical facilities construction (in \$millions)
- DSP500 $_t$  = Change in Standard and Poor's Composite Index of 500 Stocks



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**TABLE 5: BED CAPACITY REGRESSION PARAMETER ESTIMATES**  
1982 U.S. STATE AGGREGATE CROSS SECTION DATA

(Dependent Variable:  $\text{LnBED}_{i,j}$ ; Standard Errors in Parentheses)

PARAMETERS	Non-Profit Sample	For-Profit Sample	Government Sample
CONSTANT $_{i,j}$	6.45 (2.79)	-8.03 (7.09)	-6.06 (5.88)
$\text{LnHOSPSHR}_{i,j}$	-0.06 (0.08)	0.12 (0.08)	-0.09 (0.09)
$\text{LnHOSPPOP}_j$	-0.29 (0.11)	-1.03 (0.33)	-0.91 (0.25)
$\text{LnDOC}_j$	0.71 (0.22)	-0.70 (0.64)	0.98 (0.44)
$\text{LnINC}_j$	-0.56 (0.34)	1.74 (0.85)	0.87 (0.67)
$\text{LnPRICE}_j$	-0.31 (0.22)	-0.43 (0.57)	-1.40 (0.40)
$\text{PINS}_j$	0.00 (0.01)	0.03 (0.02)	0.02 (0.02)
$\text{PCOL}_j$	-0.03 (0.02)	0.00 (0.05)	-0.02 (0.04)
$\text{PMETRO}_j$	0.01 (0.00)	-0.01 (0.01)	-0.01 (0.01)
$\text{RATEREG}_j$	-0.12 (0.10)	0.11 (0.33)	-0.14 (0.20)
$\text{PCON}_j$	0.00 (0.00)	-0.01 (0.01)	-0.00 (0.00)
$\text{LnHBURT}_j$	0.02 (0.14)	-0.01 (0.42)	0.41 (0.30)
Number of Obs.	51	42	47
R <sup>2</sup>	0.83	0.51	0.77
Adj. R <sup>2</sup>	0.78	0.33	0.70

VARIABLE DEFINITIONS (All variables are calculated for a given state j):

$\text{LnBED}_{i,j}$  = Log of the average hospital bed capacity in the *i*th ownership category

$\text{LnHOSPSHR}_{i,j}$  = Log of the market share of hospitals of the *i*th ownership category

$\text{LnHOSPPOP}_t$  = Log of the total number of hospitals per capita in state

$\text{LnDOC}_t$  = Log of the number of physicians per 100,000 resident population

$\text{LnINC}_t$  = Log of real personal income per capita (in constant 1972 dollars)

$\text{LnPRICE}_t$  = Log of the average daily room charge in non-govt. short-term general hospitals (in \$)

$\text{PINS}_t$  = Percent of all personal health care expenditures covered by Medicare, Medicaid, and private insurance

$\text{PMETRO}$  = percent of population living in a metropolitan area

$\text{PCOL}$  = Percent of population age 25 and over that have completed at least four years of college

$\text{RATEREG}_j$  = 1 if state has mandatory rate regulation; 0 otherwise.

$\text{LnHBURT}_j$  = Log of federal Hill-Burton funding per facility from 1947 to 1971 (in \$thousands)

$\text{PCON}_j$  = Percent dollar volume of Certificate Of Need applications approved

## SECTION IV. THE RELATIONSHIP BETWEEN CAPACITY AND UTILIZATION

This section presents an analysis of the relationship between capacity and utilization in hospitals. In industries characterized by random demand and uncertain availability, the quantity supplied by a firm and the quantity demanded by the market are necessarily intertwined. The recognition of these features have had important implications to the study of airlines, trucking, retailing, and hospitals. In these environments, the supply decision of firms that are concerned with the costs of inventory and excess capacity will depend on not only the market price, but also the stochastic nature of demand. Similarly, the amount that firms are willing to supply will clearly affect the demand of consumers who care about the probability of obtaining a good or the waiting time required before a purchase can be made. Thus, any analysis of the relationship between supply and demand in these industries must begin with this interdependence in mind.

A well-known stylized fact in these industries is the positive correlation between market share in terms of quantity demanded and market share in terms of quantity supplied. Douglas and Miller (1974b), for example, found that under price regulation, an airline that had a larger share of available flights had more than its proportional share of passenger traffic. [FOOTNOTE: This phenomenon also appears to persist in unregulated markets. In supermarkets, selling floor space is positively related to average transaction size, capacity utilization, and weekly sales (Oi, 1990).]

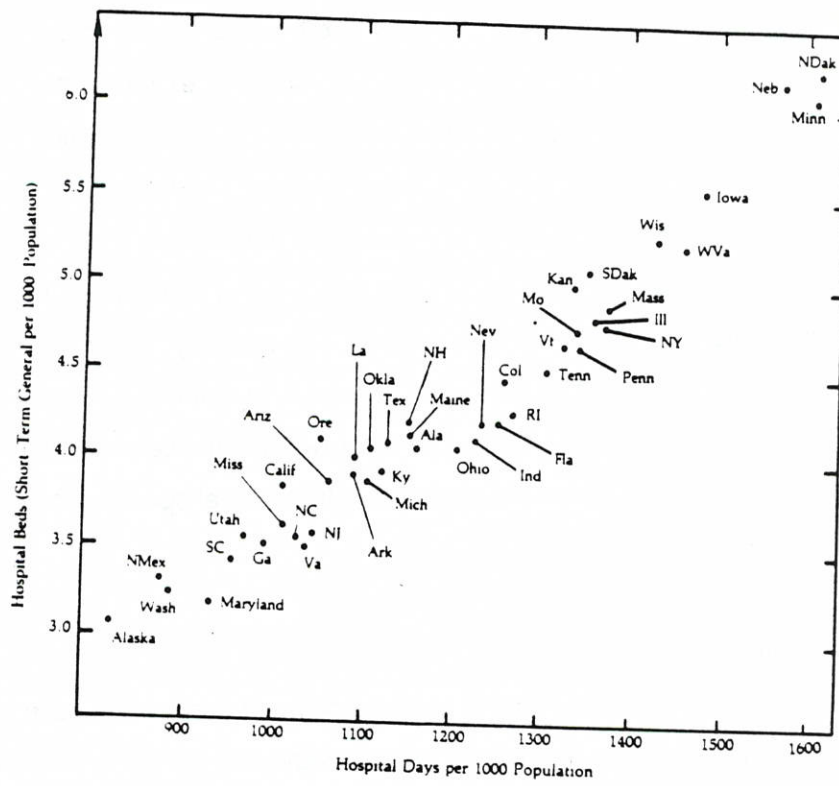
In the hospital industry, however, the analogous positive correlation between hospital bed supply and hospital use, termed Roemer's Law, has generated much controversy. Pointing to widespread insurance and imperfect information among consumers, policymakers have taken this correlation to imply that an increase in hospital capacity will lead to an increase in demand beyond the point where hospital resources are being used efficiently.

### A. Reasons for the Relationship between Hospital Bed Supply and Utilization

The positive correlation between bed supply and the number of days of hospital care provided has been well documented. As illustrated in figure 5, Shain and Roemer's (1959) finding was replicated by Stevenson (1979) using state aggregate data 20 years later. Using better technique and data, Ginsburg and Koretz (1983) also confirm Roemer's Law. Empirical studies of hospital utilization have also provided consistent support of Roemer's claim. Chiswick (1976), for example, finds the elasticity of total days of care with respect to beds to be 0.85. Freund et. al. (1985), and Robinson and Luft (1985) are further examples of such work. It is with these consistent results that policymakers have placed so much importance on the supply of beds as a fundamental determinant of hospital utilization and therefore costs.

FIGURE 5.

### Hospital Bed Supply and Utilization





Although the positive correlation between bed supply and hospital utilization has been well established, explaining the causal relationship has not. Five reasons have been suggested in the literature as to why the relationship exists. First, the current demand for hospital care may exceed supply and the increase in beds that is associated with an increase in utilization may simply be an adjustment towards equilibrium as hospitals expand to meet demand. Second, the correlation may represent a movement down the demand curve for hospital care. In a competitive market, an expansion in bed capacity that yields economies of scale and therefore lower average costs lowers the price of hospital care. Alternatively, if the additional beds are established in new, smaller hospitals, an increase in bed supply in an area reduces the total price of hospital care by reducing the travel costs of patients. A third hypothesis is that bed supply and hospital utilization are not causally related, but rather affected by the same set of common factors. For example, non-profit hospitals, which are on average larger in size, may also have objectives and characteristics that lead to a greater number of admissions or the admission of sicker patients needing longer lengths of stay. Fourth, an increase in beds induces a hospital to increase its admissions in an effort to reach an optimal occupancy rate or target rate of return. This is the demand inducement hypothesis. Fifth, if hospitals compete in quality dimensions, an expansion in bed capacity may also increase demand if capacity is synonymous with quality. This has been argued to be the case in many industries where demand is uncertain and availability important. The latter two hypotheses merit further attention, and the basic theoretical points are summarized below. More formal specification of the two alternative hypotheses is in progress.

#### A1. Non-Price Competition

The idea that sellers are somehow able to shift the demand curves they face is not new. The literature on excess capacity has also had a long history, beginning with Chamberlain's (1933) model of monopolistic competition, which tried to relate expenditures on demand-increasing costs (advertising) to excess capacity. In a later critique, Demsetz (1964) argued that monopolistic competition arising from such costs do not imply excess capacity. Rejection of Chamberlain's excess capacity theorem follows if, over some output rates, higher levels of expenditures on demand-increasing costs are associated with higher rates of output. Thus, economists have long recognized that firms can expend resources to increase demand and that such expenditures need not result in excess capacity costs.

In industries where demand is stochastic, however, excess capacity may be efficient. General treatments of the issue of capacity utilization in conditions of demand uncertainty include work by Carlton (1978). Not only is excess capacity optimal, but applications of queuing theory to economics has also led to the acceptance of a concept called the economy of massed reserves. As theory might

suggest, hospitals typically operate with excess capacity. De Vany (1976) and Mulligan (1983) also clearly illustrate that as the scale of output rises, a firm can reduce its inventory level or its proportion of reserves to expected output. Due to these scale economies, theory suggests that larger sized firms should have higher capacity utilization rates. Again, as theory suggests, occupancy rates in hospitals rise with bed capacity. Both of these empirical regularities are documented in Table 1.

In many industries with random demand, availability becomes an important attribute of the good. Patients may place value on rapid admission or a low probability that a hospital will be full and patients turned away. Although patients are rarely turned away from hospitals in the United States, evidence from other countries suggests that this is not uncommon. Other costs to patients include the expected waiting time before a patient can be admitted or the expected delay in treatment due to overcrowding and congestion in the hospital once the patient is admitted. Physicians may also prefer to admit their patients quickly and to treat their patients with a minimum of delay in their own time.

In industries of this type, non-price competition can induce a positive relationship between capacity and utilization. Although this argument assumes that hospitals do not compete on price, the assumption is not entirely unjustified. With extensive insurance coverage in the population, price may not be an important consideration to consumers (and to their physicians to the extent that physicians determine the choice of hospital) in determining their choice of hospital. Furthermore, if contracting for third-party payments is costly, prices may be inflexible. Although prices will eventually respond to permanent shifts in supply and demand, they may not be easily adjusted at each point in time. All of the above suggest that hospitals may take prices as given and that existing institutional arrangements may discourage competition on the basis of price. Instead, hospitals may compete for patients (and their physicians) by increasing the quality and scope of the facilities and services offered. For example, service rivalry may take place in availability of hospital staff, the hiring of certified physicians, technological innovation, cleanliness of facilities, advertising, food quality, and room amenities. More relevant to the question in this paper is the increase in quality due to an increase in capacity. Hospitals may increase capacity in an effort to improve quality in terms of the reduced probability of being denied admission and the reduced waiting time in treatment.

To summarize, increases in capacity results in an increase in market share since an increase in quality will attract patients away from other rival hospitals and induce new patients to be hospitalized. Conventional economic theory suggests that in markets where demand is uncertain and availability important, firms may compete for customers on the basis of availability by expanding capacity. In these circumstances, excess capacity is not inefficient, but the means by which a firm attains its desired level of availability or quality.



An alternative hypothesis is that of demand inducement, which rests on imperfect information among consumers. Consumers who are ignorant of their medical needs can be persuaded into being hospitalized. It is important to note that this does not imply that hospitals and physicians are violating professional ethics, nor does this imply that hospital resources are being misused when less critically ill patients are being hospitalized when alternative non-hospital treatments are available. The diagnosis and treatment of a particular illness is presumably more effective in a hospital, and this benefits both the individual patient and the community in general. The issue is whether the cost of the treatment provided yields the commensurate gain.

In the physician services literature on demand inducement, the "target-income hypothesis" has received the most attention. To summarize, as the market for physicians' services deteriorates through increased supply, physicians increase demand in an effort to maintain a given desired level of income. They are able to do so by taking advantage of their patients' lack of information regarding their medical needs. As many authors have noted, the mechanism by which this increase in demand occurs has not been adequately specified [FOOTNOTE: Saving (1980) and Ramsey (1983) summarize the criticisms of the theoretical and empirical models to date.]

#### B. An Empirical Study of the Determinants of Hospital Utilization

The empirical evidence on the relationship between ownership and performance generally suggests that the private sector is more efficient than the public sector. In the health economics literature, similar results are obtained, although the difficulty in capturing differences in service quality make interpretation of the results tenuous. Furthermore, as Boardman and Vining (1989) point out, most studies are of regulated industries, where it is difficult to disentangle the consequences of regulation from the consequences of ownership.

In empirical studies of ownership, it may be important to consider the choice of ownership structure as endogenous. In other words, ownership and performance may be determined simultaneously. If a hospital is facing dropping admissions, for example, a hospital may switch its ownership status. The difficulty lies in the possibility that ownership status may be related to unmeasured determinants of productivity. In the results presented below, I do not correct for the selection bias that may result if the choice of organizational form is endogenous.

The issue of simultaneity that I do address concerns the relationship between performance and size. In markets where demand is random and availability important, hospital utilization may depend on hospital capacity. On the other hand, hospital capacity may also depend on hospital utilization. Higher levels of utilization may give hospitals greater opportunity to expand. Estimation by OLS in



these circumstances results in inconsistent parameter estimates. The problem stems from the correlation between hospital capacity and the random elements that affect hospital utilization. If the level of utilization and hospital bed capacity are determined simultaneously, an unexpected shift in the demand for utilization also affects the level of hospital capacity.

Instrumental variable regression techniques are applied in an effort to obtain consistent parameter estimates. More specifically, in a regression where hospital utilization is the dependent variable, hospital capacity must be treated as an endogenous explanatory variable. The solution is to use a suitable "instrument" that is correlated with hospital capacity but independent of the random elements that may affect utilization. An appropriate instrumental variable may be constructed by two-stage least squares. The general technique is to regress hospital capacity on all of the exogenous variables in the model. This reduced-form regression yields a predicted bed capacity variable, which hopefully is not correlated with the error terms, but still correlated with actual capacity. Use of this predicted bed capacity variable in the original utilization regression function will yield consistent estimates of the determinants of hospital utilization.

The issue that remains, however, is one of identification. In a regression of hospital utilization on hospital capacity, it is not obvious whether our regression is of the demand for hospital inpatient days or the supply of hospital inpatient days. The objective of this study is to estimate the demand for hospital utilization. Identification of the demand curve requires our ability to capture shifts in the supply curve over time while the demand curve remains stable. Only then will the observed data trace out the corresponding demand curve.

In the time-series analysis, I use the following variables to identify the demand curve: 1) the prime interest rate as a proxy for the cost of debt capital, 2) the S&P 500 Index as a proxy for the cost of equity capital, and 3) the level of government expenditures on hospital construction. These variables are expected to shift the supply curve, but not the demand for hospital utilization.

### C. The Correlation Between Hospital Bed Supply and Utilization

A positive correlation between the number of hospital inpatient days per population and the number of beds per population does not imply a positive correlation between inpatient days and the number of beds. Furthermore, the correlation does not imply a positive relationship between inpatient days and hospital capacity.

The cross-section and time-series data reported in Tables 6 and 7, however, show that the correlation between aggregate bed supply and aggregate inpatient days in each ownership category is nearly perfect. The same holds between bed capacity and inpatient days per hospital. Although Roemer's Law appears to hold similarly across ownership categories, differences appear when

TABLE 6: CORRELATION MATRIX: Hospital Bed Supply and Inpatient Days  
1982 CROSS SECTION OF U.S. STATE AGGREGATE DATA

A. NON-PROFIT HOSPITALS

	DAYS	DAYS/HOSP	DAYS/BED	ADM	ADM/HOSP	LOS	BEDS	BED/HOSP
DAYS	1.00							
DAYS/HOSP	0.48	1.00						
DAYS/BED	0.40	0.84	1.00					
ADM	0.99	0.45	0.36	1.00				
ADM/HOSP	0.39	0.95	0.78	0.40	1.00			
LOS	0.41	0.50	0.53	0.33	0.22	1.00		
BEDS	1.00	0.46	0.36	0.99	0.38	0.39	1.00	
BED/HOSP	0.48	0.99	0.80	0.47	0.96	0.47	0.47	1.00

B. FOR-PROFIT HOSPITALS

	DAYS	DAYS/HOSP	DAYS/BED	ADM	ADM/HOSP	LOS	BEDS	BED/HOSP
DAYS	1.00							
DAYS/HOSP	0.17	1.00						
DAYS/BED	0.13	0.72	1.00					
ADM	0.99	0.13	0.10	1.00				
ADM/HOSP	0.17	0.93	0.63	0.15	1.00			
LOS	-0.09	-0.01	0.02	-0.11	-0.27	1.00		
BEDS	0.99	0.13	0.09	1.00	0.15	-0.10	1.00	
BED/HOSP	0.19	0.95	0.52	0.16	0.93	-0.03	0.16	1.00

C. GOVERNMENT HOSPITALS

	DAYS	DAYS/HOSP	DAYS/BED	ADM	ADM/HOSP	LOS	BEDS	BED/HOSP
DAYS	1.00							
DAYS/HOSP	0.12	1.00						
DAYS/BED	0.30	0.72	1.00					
ADM	0.98	0.02	0.19	1.00				
ADM/HOSP	0.27	0.93	0.74	0.19	1.00			
LOS	-0.20	0.47	0.35	-0.30	0.21	1.00		
BEDS	0.99	0.07	0.24	0.99	0.22	-0.23	1.00	
BED/HOSP	0.13	1.00	0.71	0.03	0.94	0.45	0.08	1.00

VARIABLE DEFINITIONS (Calculated for each ownership category in each state):

DAYS = Total Number of Inpatient Days

DAYS/HOSP = Average Number of Inpatient Days per Hospital

DAYS/BED = Average Number of Inpatient Days per Bed

ADM = Total Number of Admissions

ADM/HOSP = Average Number of Admissions per Hospital

LOS = Average Length of Stay

BEDS = Total Number of Hospital Beds

BEDS/HOSP = Average Hospital Bed Capacity



TABLE 7: CORRELATION MATRIX: Hospital Bed Supply and Inpatient Days  
1946-1983 TIME SERIES OF U.S. AGGREGATE DATA

A. NON-PROFIT HOSPITALS

	DAYS	DAYS/HOSP	DAYS/BED	ADM	ADM/HOSP	LOS	BEDS	BED/HOSP
DAYS	1.00							
DAYS/HOSP	0.99	1.00						
DAYS/BED	0.52	0.52	1.00					
ADM	0.99	0.98	0.46	1.00				
ADM/HOSP	0.99	0.99	0.44	0.99	1.00			
LOS	0.05	0.12	0.56	-0.06	-0.02	1.00		
BEDS	1.00	0.99	0.47	1.00	0.99	0.01	1.00	
BED/HOSP	0.98	1.00	0.45	0.98	0.99	0.07	0.99	1.00

B. FOR-PROFIT HOSPITALS

	DAYS	DAYS/HOSP	DAYS/BED	ADM	ADM/HOSP	LOS	BEDS	BED/HOSP
DAYS	1.00							
DAYS/HOSP	0.99	1.00						
DAYS/BED	0.09	0.14	1.00					
ADM	0.99	0.98	-0.02	1.00				
ADM/HOSP	0.99	1.00	0.08	0.99	1.00			
LOS	0.72	0.74	0.64	0.62	0.68	1.00		
BEDS	0.99	0.98	-0.04	1.00	0.98	0.63	1.00	
BED/HOSP	0.99	1.00	0.04	0.99	1.00	0.68	0.99	1.00

C. GOVERNMENT HOSPITALS

	DAYS	DAYS/HOSP	DAYS/BED	ADM	ADM/HOSP	LOS	BEDS	BED/HOSP
DAYS	1.00							
DAYS/HOSP	-0.78	1.00						
DAYS/BED	-0.08	0.29	1.00					
ADM	0.98	-0.79	-0.19	1.00				
ADM/HOSP	0.52	-0.12	-0.05	0.61	1.00			
LOS	-0.88	0.82	0.23	-0.94	-0.67	1.00		
BEDS	0.99	-0.80	-0.22	0.99	0.52	-0.90	1.00	
BED/HOSP	-0.78	0.94	-0.05	-0.76	-0.12	0.78	-0.76	1.00

VARIABLE DEFINITIONS (Calculated for each ownership category in each year):

DAYS = Total Number of Inpatient Days

DAYS/HOSP = Average Number of Inpatient Days per Hospital

DAYS/BED = Average Number of Inpatient Days per Bed

ADM = Total Number of Admissions

ADM/HOSP = Average Number of Admissions per Hospital

LOS = Average Length of Stay

BEDS = Total Number of Hospital Beds

BEDS/HOSP = Average Hospital Bed Capacity



inpatient days are analyzed in terms of its components: average length of stay and admissions. Are the increases in bed capacity correlated with increased admissions or with increases patient lengths of stay? Inpatient days are defined to be the number of adult and pediatric days of care, excluding care for newborns. Average length of stay, admissions, and inpatient days are related in the following way:

$$\text{Inpatient Days} = (\text{Average Length of Stay})(\text{Admissions})$$

The time-series evidence on this matter suggests that bed capacity is positively correlated with admissions in non-profit and for-profit hospitals, but negatively related with admissions in government hospitals. Furthermore, bed capacity is positively correlated with patient length of stay in for-profit and government hospitals, but negatively related with length of stay in non-profit hospitals. [FOOTNOTE: The use of the aggregate cross-section data presented in Table 6 to compare utilization patterns between non-profit, for-profit, and government hospitals is not advised since many geographical factors besides bed supply (such as income and demographics) are also important determinants of overall hospital utilization.] In sum, the correlations between capacity and utilization suggest that the correlation is strong and that organizational incentives may explain some differences in capacity utilization.

#### D. The Relationship Between Capacity and the Utilization Rate

In this study, the utilization rate is defined as the number of inpatient days per 1000 population. The components of utilization, the average length of stay and admissions per 1000 population, are analyzed separately. The objective is to determine whether average bed capacity influences the utilization rate. It is thus essential that the utilization rate attributed to an area reflect the level of utilization of the population residing in that area. If not, a "border-crossing" problem may occur. The utilization rate for Lawrence, Kansas, for example, may be excessively high if the population number attributed to that city is less than the market area of the local hospital. The local hospital may attract patients from the surrounding rurality that are not counted as part of the population of the city. The use of aggregate data has the advantage of reducing the magnitude of this problem. The border crossing problem is likely to be small in the U.S. aggregate time-series data, since the utilization and population figures are for the entire United States.

A problem arises with the use of aggregate data, however, and this is made clearer below. We wish to study the following relationship between hospital capacity and the utilization rate:

$$\text{UTILIZATION RATE}_{it} = (\text{DAYS}_{it}/\text{POP}_{it}) = k(\text{BEDS}_{it}/\text{HOSP}_{it}) = \text{CAPACITY}_{it} \quad (18)$$

where  $k$  is some constant and the subscript  $i$  refers to the  $i$ th ownership category and  $t$  refers to time  $t$ . The problem is the following: although data exists for each ownership category  $i$  in each year  $t$  on the average bed capacity ( $\text{BEDS}_{it}/\text{HOSP}_{it}$ ) and total utilization level ( $\text{DAYS}_{it}$ ), we do not have data on the relevant population figure of the market served by each ownership category (i.e.  $\text{POP}_{it}$ ). Instead, only the aggregate population figure ( $\text{POP}_t$ ) is available for each year. If we want to look at the relationship given by (18), analyzing the relationship

$$\text{DAYS}_{it}/\text{POP}_t = k(\text{BEDS}_{it}/\text{HOSP}_{it}) \quad (19)$$

is not valuable unless we control for market share. To make this clear, we can break the  $\text{DAYS}_{it}/\text{POP}_t$  ratio into its components as follows:

$$\text{DAYS}_{it}/\text{POP}_t = (\text{DAYS}_{it}/\text{POP}_{it})(\text{POP}_{it}/\text{HOSP}_{it}) (\text{HOSP}_{it}/\text{HOSP}_t) (\text{HOSP}_t/\text{POP}_t) \quad (20)$$

We can analyze the desired relationship described by equation (18) with the empirical relationship in (19) if we can adequately capture the unwanted variation in  $\text{DAYS}_{it}/\text{POP}_t$ . As seen in (20), the three unwanted sources of variation are 1) the hospital market share of the  $i$ th ownership category:  $\text{HOSP}_{it}/\text{HOSP}_t$ ; 2) the aggregate hospital to population ratio:  $\text{HOSP}_t/\text{POP}_t$ ; and 3) the population served by each hospital:  $\text{POP}_{it}/\text{HOSP}_{it}$ . If I assume that the population served by a single hospital (i.e.  $\text{POP}_{it}/\text{HOSP}_{it}$ ) is constant from year to year and if I include the variables  $\text{HOSP}_{it}/\text{HOSP}_t$  and  $\text{HOSP}_t/\text{POP}_t$  in my regression analysis of equation (19), then the analysis of equation (19) using aggregate data provides us information regarding the desired relationship given in (18).

#### E. Ownership and Hospital Utilization

Table 8 gives the results of our two-stage least squares estimation of the demand for hospital inpatient days. The first-stage regression predicting the level of hospital bed capacity is given in

PARAMETERS	Non-Profit Sample	For-Profit Sample	Government Sample
CONSTANT <sub>i,t</sub>	-3.14 (1.89)	0.86 (3.04)	-0.51 (1.12)
LnBED <sub>i,t</sub>	0.14 (0.53)	0.52 (0.20)	2.54 (0.64)
LnHOSPSHR <sub>i,t</sub>	0.99 (0.59)	0.37 (0.19)	1.39 (0.37)
LnHOSPPOP <sub>t</sub>	0.67 (0.36)	1.28 (0.39)	2.35 (0.48)
LnDAY <sub>i,t-1</sub>	0.97 (0.25)	0.23 (0.15)	-0.00 (0.20)
LnDOC <sub>t</sub>	0.07 (0.08)	0.44 (0.32)	-0.07 (0.13)
LnINC <sub>t</sub>	0.20 (0.15)	0.14 (0.28)	-0.35 (0.15)
LnRPRICE <sub>t</sub>	-0.28 (0.11)	0.08 (0.28)	0.14 (0.13)
PINS <sub>t</sub>	0.00 (0.00)	-0.00 (0.00)	0.01 (0.00)
DW	2.40	1.51	1.67
R <sup>2</sup>	1.00	0.99	0.93
Adj. R <sup>2</sup>	0.99	0.98	0.91

VARIABLE DEFINITIONS (All variables are calculated for a given year t):

LnDAY<sub>i,t</sub> = Log of the number of inpatient days for ith ownership category per total U.S. population

LnBED<sub>i,t</sub> = Log of the predicted average hospital bed capacity in the ith ownership category

LnHOSPSHR<sub>i,t</sub> = Log of the market share of hospitals of the ith ownership category

LnHOSPPOP<sub>t</sub> = Log of the total number of U.S. hospitals per total U.S. population

LnDOC<sub>t</sub> = Log of the number of physicians per 100,000 resident population

LnINC<sub>t</sub> = Log of real disposable personal income per capita (in constant 1982 dollars)

LnRPRICE<sub>t</sub> = Log of the ratio of the Medical Care Consumer Price Index to the Consumer Price Index

PINS<sub>t</sub> = Percent of all private consumer expenditures on health care covered by private insurance.



TABLE 9: ESTIMATES OF DYNAMIC DEMAND ADJUSTMENTS  
1949-1983 U.S. AGGREGATE TIME SERIES DATA

A. Estimated Utilization Adjustment Parameters

UTILIZATION	Non-Profit Sample	For-Profit Sample	Government Sample
$\text{LnDAY}_t$	0.97	0.23	-0.00
$\text{LnLOS}_t$	0.80	0.57	0.71
$\text{LnADM}_t$	0.55	-0.08	0.35

NOTE: The adjustment parameter measures the extent to which current utilization reflects past rather than desired levels of demand.

B. Estimated Short Run Elasticities of Utilization with respect to Capacity

DEMAND FACTORS	Non-Profit Sample	For-Profit Sample	Government Sample
$\text{LnDAY}_t$	0.14	0.52	2.54
$\text{LnLOS}_t$	-0.13	0.00	0.90
$\text{LnADM}_t$	0.83	0.80	0.79

B. Estimated Long Run Elasticities of Utilization with respect to Capacity

DEMAND FACTORS	Non-Profit Sample	For-Profit Sample	Government Sample
$\text{LnDAY}_t$	4.67	0.68	2.54
$\text{LnLOS}_t$	-0.65	0.00	3.10
$\text{LnADM}_t$	1.84	0.74	1.22

VARIABLE DEFINITIONS (All variables are calculated for a given year t):

- $\text{LnBED}_{i,t}$  = Log of the average hospital bed capacity in the ith ownership category
- $\text{LnDAY}_{i,t}$  = Log of the number of inpatient days for the ith ownership category per total U.S. capita
- $\text{LnLOS}_{i,t}$  = Log of the average length of stay in hospital for the ith ownership category
- $\text{LnADM}_{i,t}$  = Log of the number of admissions per total U.S. capita for the ith ownership category

Table 2. The predicted value for capacity from this regression is included as a regressor in the estimated equation presented in Table 8. The results suggest that a given increase in capacity increases utilization the most in public hospitals. The estimated short-run elasticity of utilization with respect to beds is 2.54 in the category of public hospitals, while it is below one for hospitals in the private sector.

The model that is estimated is also a partial adjustment model. Utilization may not react to changes in capacity immediately. Various institutional rigidities and technological factors may make the practice of medicine difficult to alter over time. The results presented in Table 9 suggest that the utilization rate in non-profit hospitals does not adjust very quickly, while the adjustment is almost immediate in public hospitals and relatively quick in for-profit hospitals. The results also find that the speed of adjustment in admissions levels is faster than that of average length of stay. This is not surprising, given the importance of technology on medical practice. These results may or may not be a contradiction with our current experience with the prospective payment system. In an analysis of the effects of prospective payment, Cutler (1990) finds that average length of stay changes more than admissions levels in response to prospective payment. This certainly deserves further thought.

The most striking result is the long-run elasticity of utilization with respect to capacity. In both non-profit and public hospitals, utilization increases dramatically as a result of an expansion in capacity. The elasticity is 4.67 in non-profit hospitals and 2.54 in public hospitals. The elasticity is less than one in for-profit hospitals.

#### F. Controlling for Hospital Casemix

Again, the increase in utilization may be affected by hospital casemix. The correlations between bed capacity and both admissions and length of stay that are shown in Tables 6 and 7 suggest that casemix may be critical. Table 10 gives the results of a two-stage estimation procedure using first differences, with the predicted change in capacity coming from the regressions shown in Table 4. The analysis confirms the strong positive relationship between capacity and utilization in public hospitals, though the magnitude is much smaller, where the estimated elasticity is close to one. In contrast, the elasticity is 0.77 in for-profit hospitals and possibly negative in non-profit hospitals. The results, however, are largely insignificant, and further work is needed here. One distinguishing result is the positive effect of capacity on utilization in for-profit and public hospitals. A second result consistent with the previous tables is the large effect of past utilization on current utilization in non-profit hospitals. I interpret this as evidence that non-profit hospitals do not adjust their utilization rate very quickly. In sum, the general results presented earlier remain unchanged.

TABLE 10: HOSPITAL UTILIZATION REGRESSION PARAMETER ESTIMATES  
1949-1983 U.S. AGGREGATE TIME SERIES DATA

(Dependent Variable:  $DDAY_{i,t}$ ; Standard Errors in Parentheses)

PARAMETERS	Non-Profit Sample	For-Profit Sample	Government Sample
CONSTANT $_{i,t}$	0.05 (0.03)	0.01 (0.02)	0.00 (0.01)
DBED $_{i,t}$	-4.86 (3.94)	0.77 (0.40)	0.92 (0.78)
DHOSPSHR $_{i,t}$	-2.75 (2.92)	0.73 (0.24)	0.76 (0.46)
DHOSPPOP $_t$	-2.69 (2.49)	1.32 (0.45)	1.39 (0.55)
DDAY $_{i,t-1}$	1.82 (1.07)	0.00 (0.13)	-0.16 (0.14)
DDOC $_t$	-0.20 (0.17)	-0.01 (0.29)	0.01 (0.17)
DINC $_t$	0.71 (0.48)	-0.14 (0.36)	0.03 (0.23)
DRPRICE $_t$	-0.68 (0.35)	-0.17 (0.32)	-0.13 (0.18)
DPINS $_t$	0.00 (0.00)	0.00 (0.01)	-0.00 (0.00)
DW	2.35	1.46	1.44
R <sup>2</sup>	0.37	0.65	0.60
Adj. R <sup>2</sup>	0.17	0.54	0.47

VARIABLE DEFINITIONS (All variables are calculated as first differences between year t and year t-1 of the logarithms):

- DDAY $_{i,t}$  = Change in inpatient days for the ith ownership category per total U.S. population
- DBED $_{i,t}$  = Predicted change in average hospital bed capacity in the ith ownership category
- DHOSPSHR $_{i,t}$  = Change in market share of hospitals of the ith ownership category
- DHOSPPOP $_t$  = Change in the total number of U.S. hospitals per total U.S. population
- DDOC $_t$  = Change in the number of physicians per 100,000 resident population
- DINC $_t$  = Change in real disposable personal income per capita (in constant 1982 dollars)
- DRPRICE $_t$  = Change in ratio of the Medical Care Consumer Price Index to the Consumer Price Index
- DPINS $_t$  = Change in the percent of private consumer expenditures on health care covered by private insurance.



## SECTION V. CONCLUSION

This paper looked at the capacity choice problem in non-profit, for-profit, and public hospitals. The paper identified two sources of hospital cost inflation: the supply effect, where hospitals overinvest in bed capacity, and the consumption effect, where an increase in capacity leads to greater levels of utilization. The empirical evidence in this paper provided estimates of the magnitude of each. In short, the results suggest the following.

First, both non-profit and public hospitals have greater investments in hospital bed capacity. The empirical work in this paper suggests that the short-run elasticity of capacity with respect to increases in past utilization is 0.41 in non-profit hospitals, -0.20 in for-profit hospitals, and 0.18 in public hospitals.

Second, public hospitals experience the greatest increase in utilization from a given increase in capacity. The empirical work in this paper suggests that the short-run elasticity of inpatient days with respect to increases in capacity is 0.14 in non-profit hospitals, 0.52 in for-profit hospitals, and 2.54 in public hospitals.

These results clearly show that the supply effect is larger in non-profit hospitals, while the consumption effect is larger in for-profit hospitals. Both effects are relatively large in public hospitals. The magnitude of these effects can be significant, as the following demonstration suggests.

With the above estimated elasticities, we can calculate the rise in total hospital costs resulting from a change in inpatient days due to an increase in past demand. Taking the two inflationary effects together, a one percent increase in utilization increases inpatient days the following year by 0.057 percent in non-profit hospitals and 0.457 percent in public hospitals. Since for-profit hospitals appear to reduce capacity in response, inpatient days fall by an estimated 0.104 percent. The small numbers are misleading. In 1988, non-profit hospitals provided 167.5 million days of care at a cost of \$590.95 per day. For-profit hospitals provided 19.2 million days at a cost of \$649.33 per day, and public hospitals provided 41.4 million days of hospital care at a cost of \$514.28 per day. These results should be considered preliminary, and further work is warranted. An analysis of monopoly hospital markets using hospital-level data is in progress.

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