FACTORS AFFECTING THE VARIATION IN COST INFLATION AMONG HOSPITALS WHICH EXPAND BEDS OR FACILITIES: AN ANALYSIS OF HOSPITAL REGULATION POLICY

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Hospital cost increases have been greater than any other component of the rising Consumer Price Index (CPI). While the CPI rose from 91.7 to 133.1 between 1963 and 1973 (measured in 1967 dollars), the hospital service charge rose from an average of 78.3 to 164.3.[1] This meant that a 45 percent increase in the general CPI was outmatched by a 110 percent increase in the hospital charge component.

Measures to curb this inflation have come from both the private and the public sectors of the economy. The private sector response has come mainly from large third-party insurers such as Blue Cross. Their influence is exerted directly upon the cost inflation problem through the rate setting procedures they follow and the reimbursement sanctions (or coverage exclusions) they employ. Rate regulation is also starting to be used by the public, or government, sector. Eight states presently have state rate setting authorities and the recently enacted National Health Planning and Resources Development Act of 1974 (P.L. 93-641) authorizes grants for further demonstrating the effectiveness of rate regulation in slowing hospital cost increases.[2]

But the major effort by the public sector against hospital cost inflation is the direct intervention in the hospital decision-making process through the regulation of hospital expansions. Presently, 24 states utilize "certificate of need" laws to control hospital expansions and 37 states participate in a similar federal program called Section 1122 (Amendments to the Social Security Act[3]).[4]

Expansions of hospital beds and facilities--and theoretically their associated cost inflation--are regulated in slightly different ways by the two mechanisms. In states with "certificate of need" legislation, proposed hospital expansions which will have undesirable effects upon hospital costs are refused a "franchise."[5] Without a franchise, a hospital is simply not allowed to expand facilities or services. In states participating in the Section 1122 program, proposed expansions which will have undesirable effects upon hospital costs will cause the hospital involved to lose reimbursement for activities sponsored by the Department of Health, Education, and Welfare. This threat is significant, given that expenditures for Medicare and medicaid alone constituted 34 percent of the total expenditures for hospital care in 1971.[6]

Unfortunately, as the Michigan Technical Work Group on Health Care Costs suggested in 1973, "There is general agreement that health planning is far from a fully developed and effective regulatory technique."[7] A disenchantment with planning mechanisms is in fact developing due to their inability to curb rising health expenditures and to bring about a more equitable distribution of health resources geographically.[8] It seems in general that the technical requirements of hospital regulation exceed the analytical capability of the health planning process.

An examination of the history of hospital regulation does not look encouraging in terms of closing the "requirements-capability" gap. The general desire for increased public intervention in the health care system has stimulated numerous expansions in the scope of hospital regulation. At the same time, the specific technical requirements of each new regulative effort have been increasingly difficult to meet.

In a general historical sense, the increasing public desire for hospital regulation is understandable and predictable. Hospital regulation has been, to a large extent, a result of the growing dissatisfaction in this country with the distribution of general hospital facilities. It is often argued, for example, that high costs have been caused by wasteful duplication of facilities; that poor accessibility is the result of facilities being located in the wrong places; and that general hospital service is an inefficient substitute for the care of a general practitioner. Since the hospital is crucial to the delivery of medical care, it was a logical conclusion that the regulation of hospital capacity and location would be a positive step in reshaping the medical system.

In terms of specific history, the need for analytical planning capability began in 1946 with the passage of the Hill-Burton Hospital Survey and Construction Act--an act making hospital regulation a national priority. Under this act, grants were made to states to survey existing facilities, to plan for additional facilities, and to assist in the construction of new facilities. In addition, to qualify for funds, states had to develop performance standards for those hospitals built with Hill-Burton money.

These procedures and requirements increased the public's influence over hospital behavior in two ways. First, locational and capacity decisions of hospitals were influenced by the priorities established for the allocation of construction funds. Secondly, hospitals were now forced to meet some minimum operational standards.[9] However, at this point in the regulation process, it appears that the planning capability of government was able to meet the technical requirements needed to regulate hospitals.

This balance in "capability" and "requirement" began to shift in 1965 with the passage of the Medicare and Medicaid Amendments to the Social Security Act. These programs, designed primarily to increase the availability of medical facilities to the poor and aged, gave states new regulatory power over hospitals. States were now empowered to certify acceptable and non-acceptable facilities, to perform utilization review, and to prescribe the form of certain reimbursement policies. Suddenly, without a noticeable increase in the capability to plan, the analytical requirements of the regulation process had heightened.

This situation occurred again in 1966 with the advent of the Partnership for Health Program Amendments to the Federal Public Health Service Act. Although these amendments asked only for voluntary compliance with public planning efforts, they emphasized the elimination of unnecessary duplication in facilities and equipment, a task calling for relatively technical planning when juxtaposed with the rather simple bed-needs assessment of the Hill-Burton program. They also ushered in most of the "certificate of need" legislation passed by individual states and the subsequent Section 1122 Amendments at the federal level. These programs both significantly affected hospital behavior and placed increased demands upon the planning process.

It would seem that the most recently passed health legislation, P.L. 93-641, is consistent with the history of hospital regulation discussed above. The central policies of this act include rate regulation, facility construction and modernization, expansion regulation, and improved health planning. To the extent that the first three responsibilities of the act create regulation requirements beyond the "improvements" brought about in health planning, the regulation requirements-capability gap has not been closed. That this situation is again probably true is reflected in the statement of the U.S. Department of Health, Education, and Welfare concerning P.L. 93-641, that "...effective planning [must be] built on a strong technical and methodological base. That base is almost nonexistent today."[10]

If regulation capability is ever to match the task at hand, several difficult questions must be examined. Mary Ingbar, identifying the major question surrounding expansion regulation, suggests that "...if public policy is to be successful, the first assumption that needs to be examined is that we can predict the effect on cost of controlling expansion of health facilities."[11] That is, the basic public policy proposition that hospital costs can be predictably regulated by the control of hospital expansions has not been explored. The purpose of this study is to examine this proposition.

Within this context, the specific goal of this study is to examine the relationship between hospital expansions and hospital cost increases. In statistical terms, this examination can be stated as an attempt to explain the variation in hospital cost increases among hospitals which have expanded either beds or facilities in a recent time period.

In order to be policy-useful, this study seeks to answer several questions about the expansion regulation process. First, does the addition of beds in some hospitals affect cost differently than an addition of beds in other hospitals? Second, does the addition of certain facilities systematically affect hospital costs over time? And last, if expansions do affect costs, are their effects important vis-a-vis other forces at work in the hospital?

To accomplish this, data are examined statistically on 92 short-term general Wisconsin, Iowa, and Minnesota hospitals which expanded their capacity in 1971. Cost changes in these hospitals are examined over the one-, two-, and three-year periods following their expansion. Variations in cost increases among these hospitals are explained by expansion and non-expansion related factors. But before this examination is conducted, several theoretical and conceptual steps are developed.

Chapter II of this study begins by discussing the economics of the hospital. In this discussion, hospital output is defined, resources used by the hospital are discussed, and the production function and cost curves for the short-term general hospital are described. The chapter concludes by examining how hospital expansions possibly affect hospital costs over time and how the expansion regulation process attempts to predict these changes.

Chapter III suggests that factors other than hospital expansion may in fact be causing costs to rise. Specific alternative theories of hospital cost inflation are identified, though not discussed in detail, and empirical tests of particular theories are discussed. The useful output of this chapter is a summary of various variables used in previous studies to capture the essence of several hospital cost inflation theories.

Chapter IV develops the conceptual model for the study. If the regulation process is to be successful in controlling costs, the health planner requires a model which explains hospital cost changes over time due to hospital expansions and other causes of cost inflation. The simple model developed in this chapter incorporates both sets of factors and provides the framework for the statistical model of Chapter V.

The statistical tests of the data for the 92 hospitals which expanded beds or facilities in 1971 are contained in Chapter V. Here the data sources are identified and the precise multiple regression model specified. In this chapter, the relative importance of each factor in the model upon costs over time will be determined. Here it should be known whether or not expansions in hospital capacity have any systematic effect upon hospital cost behavior.

Chapter VI concludes this study by discussing the implications of the empirical results for the expansion regulation process. At the same time, limitations of the study are noted and future directions for research are suggested.

FOOTNOTES

[1]Social Security Bulletin, 37 (1974), Tables M-35 and M-36, pp. 70-71.

[2]U.S. Department of Health, Education, and Welfare, An Analysis of State and Regional Health Regulations, Health Resources Studies No. 75-611, 1975, Table 1, p. 3.

[3]Section 1122(a) of the Social Security Amendments of 1972 (P.L. 92-603).

[4]Analysis of State Health Regulations, p. 8.

[5]Clark Havighurst, Public Utility Regulation for Hospitals (Washington, D.C., 1973), Reprint No. 17, p. 9.

[6]Julian Pettengill, "The Financial Position of Private Community Hospitals, 1961-1971," Social Security Bulletin, XXXVI (1973), Table 1, p. 4.

[7]Michigan Department of Social Services, Rising Medical Costs in Michigan: The Scope of the Problem and the Effectiveness of Current Controls (Lansing, 1973), p. 10.

[9]John Simonson, "The Determinants of Changes in the Allocation of Hospital Service Capacity: A Study in Policy Theory" (unpub. Ph.D. dissertation, University of Wisconsin, 1972), p. 12.

[10]U.S. Department of Health, Education, and Welfare, Health Planning and Resources Development Act of 1974, Health Resources Administration, No. 75-14015, 1975, p. 16.

[11]Mary Lee Ingbar, "Controlling the Expansion of Health Care Facilities in a State: The Prediction Dilemma," Proceedings of the Public Health Conference on Records and Statistics, U.S. Department of Health, Education, and Welfare, Public Health Service (Washington, D.C., 1972), pp. 338-339.

CHAPTER II

THEORETICAL RELATIONSHIP BETWEEN HOSPITAL EXPANSIONS AND HOSPITAL COST INCREASES

Introduction

Hospitals add both new beds and facilities to their existing structures on occasions and, as they do, dramatically alter the conditions under which they operate and the product which they deliver. This chapter presents the theoretical framework within which to view the relationship between hospital expansions and hospital cost changes over time. The "principles of production" in the hospital are first described so that the hospital and its changes can be subjected to economic analysis. In this description the resources used and the output produced by the hospital are discussed so that the hospital's production function can be defined. The production function is then used to derive the costs of production for the hospital.

The second major section of this chapter examines the effects of expansions of beds and facilities upon the hospital's costs of production. Suggestions are made in this discussion as to possible considerations to be included in any conceptual or empirical model of hospital cost inflation.

The chapter concludes with a brief discussion of how the theoretical relationships can be used in the expansion regulation process.

The Hospital as a Producer of Health Care

In order to understand the relationship between changes in cost and expansions in capacity or capability in the "typical" industry, the firm's "principles of production" must be understood. The relationships among the firm's costs, output, and resource use must especially be understood.

But is the general concept of "principles of production" valid in the hospital industry, where a majority of the firms are not run for profit; i.e., is the hospital an economic "firm"?[1] Greenfield cogently argues that it is, since the hospital, regardless of its profit orientation, is a user of resources and a producer of goods and services.[2] This study begins by assuming that Greenfield's premise is correct--that a hospital does have definable "principles of production." Further, it assumes that these principles or concepts will be useful in explaining the relatedness or unrelatedness of expansions to hospital cost changes over time.

The purpose of this section is to describe the principles of production in the hospital. Although these principles are not significantly different from those applied in other industries, it is somewhat surprising that these concepts have not been well articulated in the existing hospital literature. The process by which resources are used, services produced, and cost incurred is at the heart of most of the issues facing the health industry today, and a thorough understanding of this process is thus necessary.

The three principles of production discussed in this section are resource use, hospital output and the production function, and costs of production. Since costs of production and hospital output are functions of resource use, the latter shall be discussed first.

Hospital Use of Resources

Hospitals, as other firms, use both fixed and variable inputs to produce health care. The fixed resources used by a hospital include land, building, beds, and equipment. There are few estimates of the amount of each of these components for the hospital industry. In all, U.S. community hospital total assets in 1973 equaled $37.5 billion.[3] Table I shows the assets per bed in various size community hospitals in 1973. Here it is evident that total assets used per bed vary positively with size. The simple correlation between average hospital size (in the group categories) and the amount of assets per bed is 0.90 (significant at the 0.01 level). This positive relationship is thought to exist because of the "greater number of facilities and services offered by the large hospitals and the costly and complex equipment these facilities and services often require."[4]

Variable resource use by hospitals is typically composed of such items as labor (both highly skilled and unskilled), food, electricity, bandages, drugs, and other such factors whose use varies with the daily use of the hospital. Again there are few good estimates of the magnitudes of the use of each of the variable resource components.

The most estimative component of the variable resources used is labor. In 1973, over 3.0 million persons were employed full- and part-time in U.S. hospitals and received over $21.3 million as wages and benefits.[5] Table II shows the full-time equivalent personnel employed per patient day of care by size of community hospital for the entire

TABLE I

ASSETS PER BED IN COMMUNITY HOSPITALS, 1973

No. of Beds in Hospital	Assets per Bed
6- 24 beds	$24,111
25- 49 beds	23,616
50- 99 beds	29,826
100-199 beds	36,530
200-299 beds	44,169
300-399 beds	46,354
400-499 beds	48,481
500 beds and over	49,957

Source: _Hospital Statistics 1974_, Text Table 15.

TABLE II

FULL-TIME EQUIVALENT PERSONNEL USED PER PATIENT DAY IN U.S. COMMUNITY HOSPITALS BY SIZE, 1973

No. of Beds in Hospital	FTE Personnel per Patient Day
6- 24 beds	0.0078
25- 49 beds	0.0071
50- 99 beds	0.0071
100-199 beds	0.0074
200-299 beds	0.0077
300-399 beds	0.0079
400-499 beds	0.0082
500 beds and over	0.0089
Average for all community hospitals	0.0078

Source: Derived from _Hospital Statistics 1974_, Table 2.

year of 1973.[6] Although there is a slight positive relationship between hospital size and the number of full-time equivalent personnel used per patient day, on average it appears that .0078 personnel are required for each day of patient care provided throughout the year.

Ingbar and Taylor have estimated the relative size of the variable resources used in 117 Massachusetts hospitals in 1959.[7] Table III shows their estimate of the variable resource components in terms of percent of the average total variable expenditures in the Massachusetts hospitals. The first three categories, which represent their estimate of the personnel variable resource use, constitute nearly 69 percent of all variable resource expenditures made. These figures agree closely with later estimates of variable costs by Davis.[8]

TABLE III

RELATIVE SIZES OF VARIABLE COSTS PER PATIENT DAY
IN MASSACHUSETTS SHORT-TERM HOSPITALS--
INGBAR AND TAYLOR STUDY, 1959

Variable Resource	Percent of Variable Cost per Patient Day
Nursing personnel	24.3%
Administrative and maintenance personnel	17.8%
*Facility/service related personnel	26.6%
Medical and surgical supplies	3.5%
Drugs	3.5%
Food and Laundry	15.8%
Maintenance and upkeep	7.0%
Other	1.5%
	100.0%

*Personnel used for such services as laboratories, radiology, operating room, delivery room, anesthesiology, etc.

Source: Derived from Table 2.5. Ingbar and Taylor.

Currently, total payroll as a percent of total U.S. community hospital expenses is 55.6.[9] This lower proportion may be due to the fact that the "total expenditures" used in the latter figure include some debt service expenditures and due to the fact that non-payroll expenses have been increasing faster than payroll expenses.[10]

Hospital Output and the Production Function

The fixed and variable resources are combined in the hospital to produce varying types and levels of output. These input-output relationships are embodied in the production function for each hospital, which can generally be stated as:

$$Q = f(F, V_1, V_2, \ldots V_n). \quad (1)$$

In this general statement of the production function, Q represents the output of the hospital, F the fixed resources employed by the hospital, V_i the various variable resources used by the hospital, and f the relationship among F and the V_i themselves and with Q. A more complete specification of the production function for the short-term general hospital which is not useful for present purposes would include the physicians using the hospital and the health status of the hospital's service area in the right-hand argument.[11]

Before the basic relationships between the elements of the production function are explored, the definition of hospital output must be discussed.

The short-term general hospital produces a wide variety of services, including different kinds of inpatient care, highly technical diagnostic services, outpatient and emergency treatment, and, among things, teaching and research activities. Attempts at measuring this output for empirical analysis have been almost as varied as the product itself.

The most basic measure of hospital output is the patient day. This is simply the number of people using the hospital each day. When contrasted with the maximum number of persons a hospital could practicably treat each day, this measure of output is a good measure for hospital utilization.

However, in attempts to explain the variation in average costs among various hospitals, it became necessary to adjust hospital output for certain qualitative aspects. Under various forms of analysis, hospitals which provided more technical services or treated more severe ailments tended to have costs higher than other hospitals regardless of their utilization or efficiency of production, or other economic considerations of production. Thus, the definition of hospital output took on a qualitative as well as a quantitative aspect in description.

The efforts at adjusting the definition of hospital output for differences in character and complexity have been numerous. The most direct change to the basic measure (patient day) of hospital output has been that of the American Hospital Association. Beginning in 1969, inpatient and outpatient days of care were combined to represent a single measure of hospital output called adjusted patient days of care. Using this measure, several authors have explained the variation in hospital average costs by including variations in case-mix variables,[12] and the number of types of services and facilities[13] as explanatory variables.

Other definitions of hospital output have varied from the patient day measure. These include measures of hospital output which are defined by the number of times a service is provided, the number of times an illness is treated, the level of health status of persons after hospital treatment, and the level of use of intermediate inputs. Examples of each of these definitions and the context within which each of these definitions is appropriate are summarized in Berki's work.[14] The problems with each of these measures are discussed by Jeffers and Siebert,[15] and Ruchlin and Leveson.[16]

The definition of hospital output used in this study will follow that of the former group of studies which used (adjusted) patient days as the output measure. Output is defined as the number of patients using the hospital each day.[17] Differences in quality and complexity will be adjusted for in the explanatory portion of the cost inflation model which is used.[18] One of the important aspects of this study will be examining the effects of changing output complexity upon average costs.

Returning to the production function, the various inputs contained in Equation (1) can be combined in different proportions to produce varying types and levels of output. In the short run where F (by definition) is fixed, the various components of the variable inputs such as personnel and drugs can be varied so as to produce different levels of hospital output, i.e., patient days of care. By changing the quantities of all of the V_i used by the hospital, the level of output can be increased or decreased. The level of output can also be increased or decreased by changing the quantity of some inputs used while holding the level of other resources constant.

If the relationship between total hospital output and the amount of variable input used is basically identical to that of the "typical economic firm," the effects of the law of diminishing returns would suggest a total product curve as shown in Figure 1. Here, as more units of medical personnel are used with a constant level of drugs, food, beds, facilities, etc., total hospital care provided initially rises and subsequently levels off at some number of personnel such as P_m. After this point the addition of other personnel, all other things held constant, would decrease the total amount of care able to be delivered by the hospital.

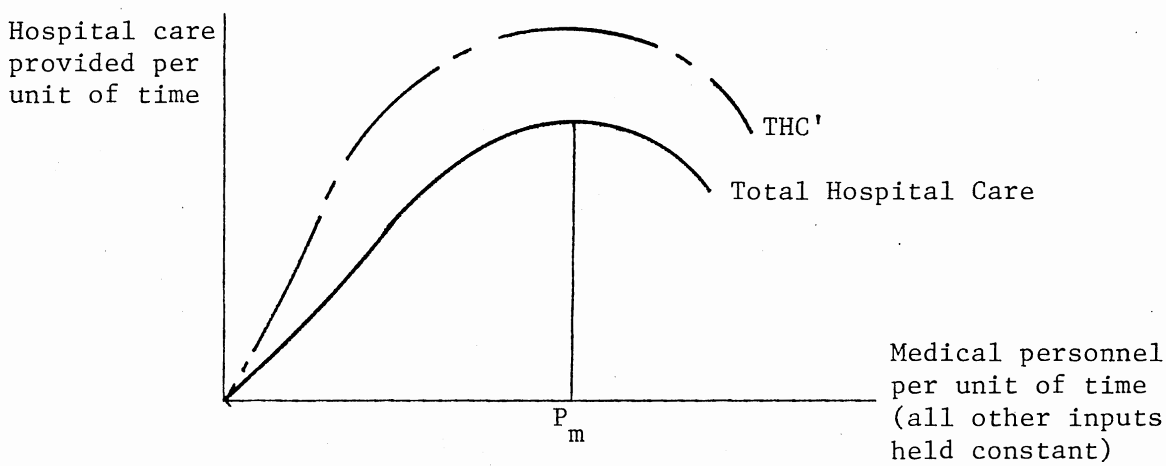


Figure 1. Total Hospital Care Delivered by Varying Only One Input

An important note for the purposes of this study is that the total product curve traced out in Figure 1 assumes a constant level of capital (as well as physicians and health status of the people). Should this (these) parameter(s) change, the path of total product would be different. For example, if the number of beds in a hospital were 100 rather than 50, the total amount of patient care provided by incrementally adding medical personnel would be greater, as indicated by the dotted line THC' in Figure 1. The maximum amount of care per unit of variable input may also change.

This example points to an important aspect of fixed capital--such as beds and facilities--in the production relationship. The amount of capital embodied in each hospital sets the upper bounds to the amount of patient care per unit of time which the hospital can provide. This amount is represented by the area under the total product curve and is a function of the level of F. This is largely why the level of F embodied in a plant is used to describe the size of a firm in conventional economics of the firm.[19]

Having discussed how hospitals combine various types of inputs to produce hospital care and how the total amount of care will increase at a decreasing rate as additional units of variable inputs are added to a constant stock of fixed capital and other variable resources, the costs of production can now be discussed.

Costs of Production in Producing Hospital Care

Given that total product in the hospital is very similar to total product in the conventional firm, there is also little difference in the concept of cost of production between the two. Just as there are fixed and variable inputs in the hospital, there are short- and long-run costs. Since the development of the concepts of costs of production in the hospital are not significantly different from that in the typical discussion of microeconomic costs of production, they shall not be exhaustively developed here. Special attention is paid in subsequent sections to the elements of the hospital cost curves which pertain to hospital expansions.[20]

In the short run, total variable cost in the hospital is a "mirror image" of the hospital's total product schedule.[21] With constant resource prices and a given level of fixed input, the various total costs are as represented in Figure 2, where the THC remains the total output of the hospital, TVC the total variable cost of different levels of personnel use, TFC is the cost of total fixed inputs or capital used by the hospital, and TC is the total cost of the hospital for producing different levels of care.

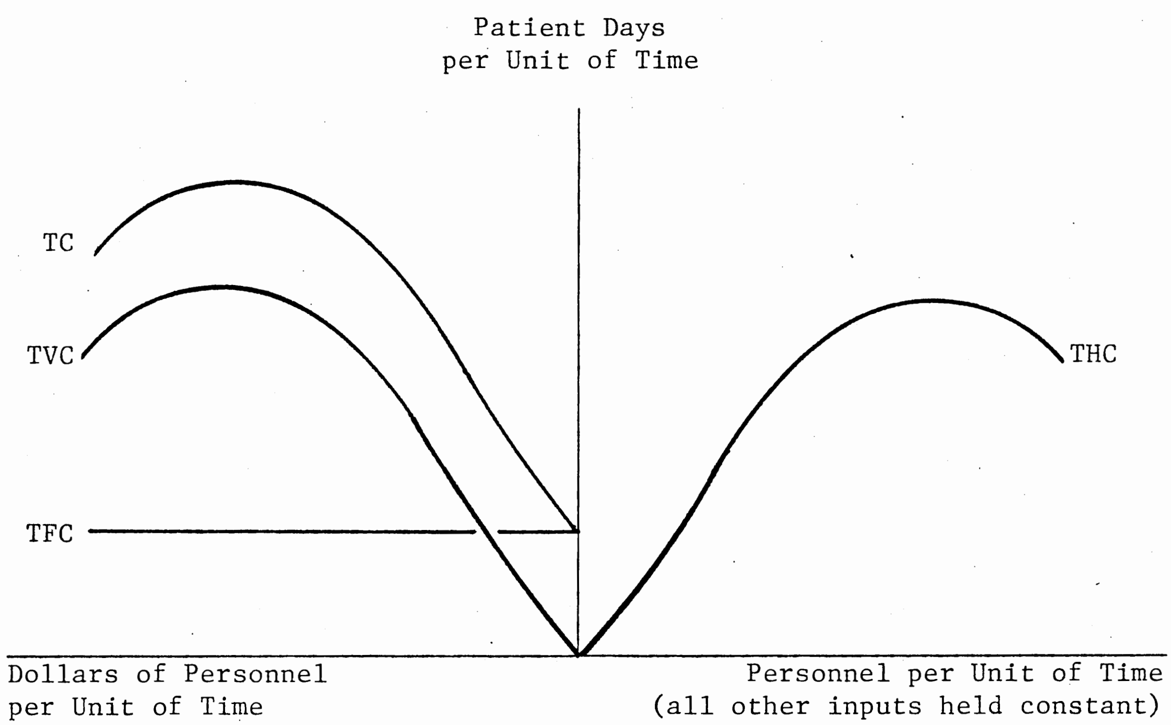


Figure 2. Relationship Among Total Hospital Product; Fixed, Variable, and Total Costs

By dividing each of the costs above by the corresponding level of output, average costs are determined. The typical short-run average total cost (ATC), average variable cost (AVC), and average fixed cost (AFC) are shown in Figure 3.

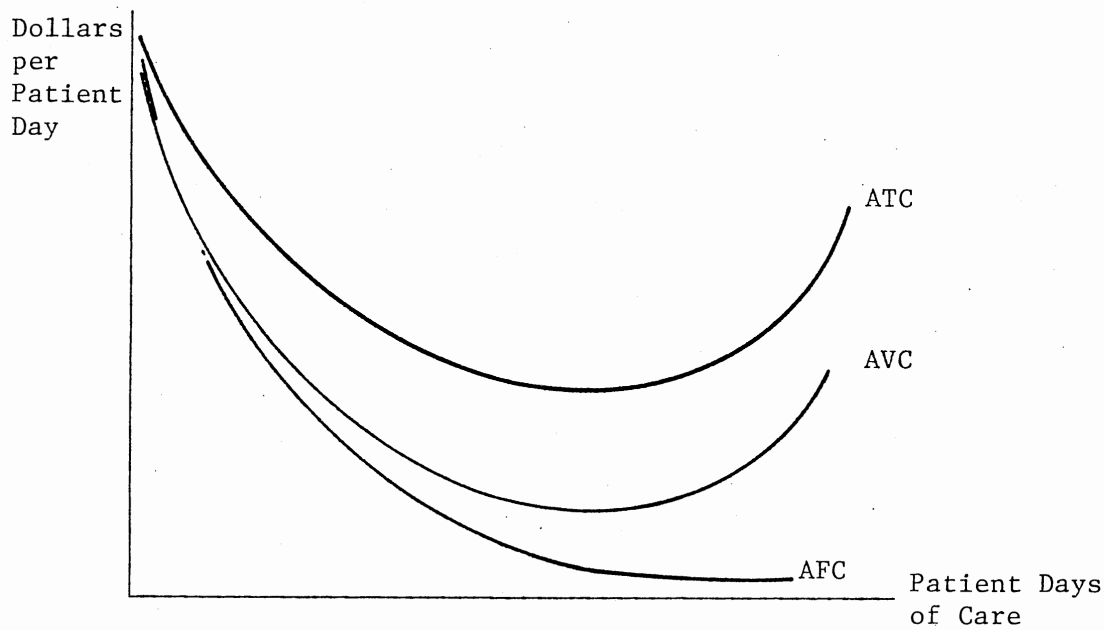


Figure 3. Short-run Average Costs in the Hospital

In the long run, the various short-run average cost schedules produced by different sizes of fixed inputs create the long-run average cost curve (LAC) or "envelope curve" for the hospital. This curve represents the locus of cost and output observations which are the least-cost combination of inputs in the production of hospital care. As shown in Figure 4, all other combinations of capital and variable inputs produce costs greater than the long-run least cost at every level of hospital output (such as Point A, which is not on the long-run average cost curve for the hospital).

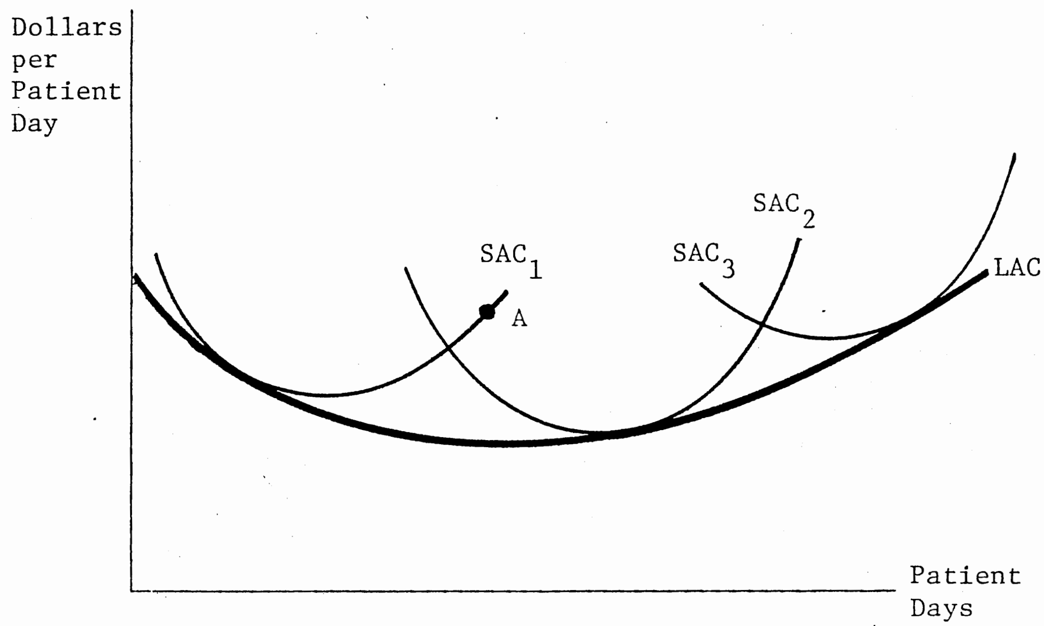


Figure 4. Relationship of Short- and Long-run Average Costs

Empirical estimates of the shape of the short-run average cost curve for hospitals have varied in their support of the above discussion. Paul Feldstein found a shallow U-shaped average cost curve in an early study of hospital costs.[22] Feldstein and Carr later found similar results with minimum average costs at an average daily census of approximately 190.[23] Cohen also found a U-shaped average cost schedule with minimum costs occurring at the 160-, 290-, or 320-bed level, depending upon the type of hospital examined and the definition of output employed.[24]

But not all empirical studies have found a U-shaped average cost curve for the hospital. Berry found a declining average cost curve over the entire range of production in the hospitals he studied,[25] and Ingbar and Taylor found the average cost curve to be a slightly inverted U-shaped curve with the maximum occurring at an average daily census of 190.[26]

In general, with the exception of the Ingbar and Taylor study noted, empirical tests support the notion that hospitals possess average cost relationships quite similar to those in other firms and industries. However, before passing on to the central topic of this study, the effect of expansions upon costs, a special subtlety of hospital cost curves and their analysis, should be noted.

The analysis of cost variation among firms in a particular industry normally assumes a uniform product in all firms. An example of this is the electrical power industry, where a kilowatt hour is a good measure of the homogeneous product, electricity. In this industry, variations in the cost of producing electricity must come from differences in the economies of scale of the various producers or in differences in their efficiency or related factors.[27] However, the same is not true of the hospital or other multiproduct industries.[28]

In the hospital industry, two hospitals may have identical levels of output, as measured by patient days, yet have different levels of average cost. This difference may be due to the same factors which affect the single-product firm, such as efficiency, or could be due to the fact that one hospital has more technical services applied to each day of care than the other, or due to the fact that the types of cases treated in the one hospital are more complex than those treated in the other hospital. This is illustrated in Figure 5, where Hospital 2 applies more technical services per day of care and treats more complicated cases than Hospital 1, yet renders the same number of patient days of care--average cost in Hospital 2 is correspondingly higher. As mentioned in the discussion of hospital output, these differences are considerations when estimating the cost functions of multi-product firms and may, to some extent, be adjusted for by including case-mix and capital intensity parameters in the explanatory side of the cost equation.

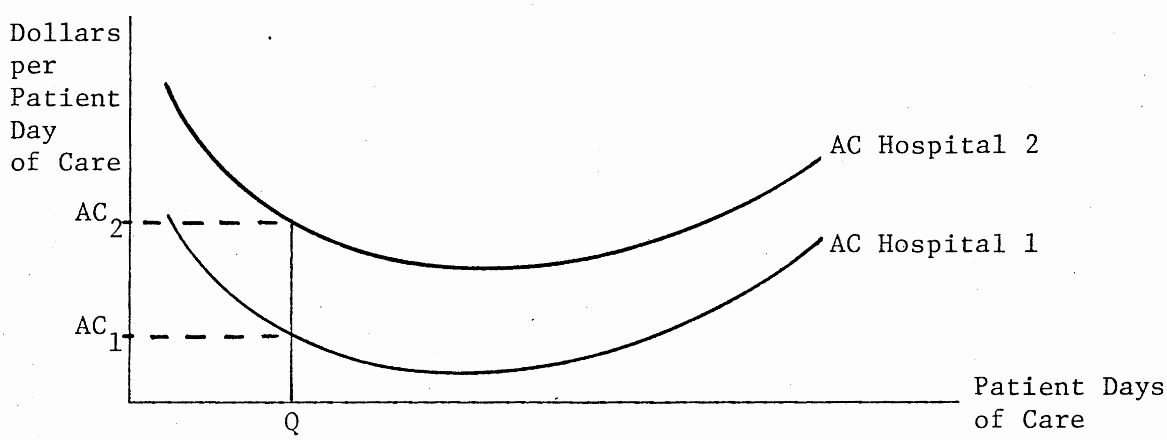


Figure 5. Average Cost in Multi-product Hospitals with Identical Levels of Output

The important distinctions to note, then, when analyzing the cost curves of multi-product hospitals is that (1) cost differences may be due to differences in resource use or in product differentiation, and (2) as Lave and Lave have cautioned, the cost function of a multi-product firm is only an approximation over a short relevant range of the hospital's output.[29]

Having discussed the hospital as a producer of hospital care and a user of resources with the associated costs of production, it is now possible to discuss the effect of hospital expansions upon hospital costs.

Effect of Expansions Upon Hospital Costs

The specific goal of this study is to test for the relationship between hospital expansions and hospital cost increases. Within the context of a hospital's cost of production, the purpose of this section is to discuss the theoretical implications of the two broad types of hospital expansions upon hospital costs. The two types of expansions which are discussed are (1) expansions in hospital beds, and (2) expansions in hospital facilities.

Expansion of Beds

The expansion of hospital beds is often thought to be the most important factor in expansion-related hospital cost inflation. Somers has suggested that every million dollars spent on construction and other large capital expenditures produces an increase in annual operating expenses of $350,000 to $700,000.[30] Ingbar assigns the costs of an unnecessary bed as $48,000 (1971) for the capital cost plus the "national average expense per patient day" (which was $81.01 per day in 1970) equaling approximately $29,500 each year.[31]

But what actually happens to a hospital's costs when it expands its number of beds? Figure 6 shows that, as in any other firm, as a hospital changes its capacity (while not changing its product), its short-run average cost curve shifts outward along its long-run average cost curve.

In the immediate period after expansion, when output in the hospital is rather rigid, it is possible for average costs to either rise or fall with the change in capacity. The direction and magnitude of the initial change in average cost depends upon the original and subsequent position of the short-run average cost curve vis-a-vis the long-run average cost curve and the level of output.

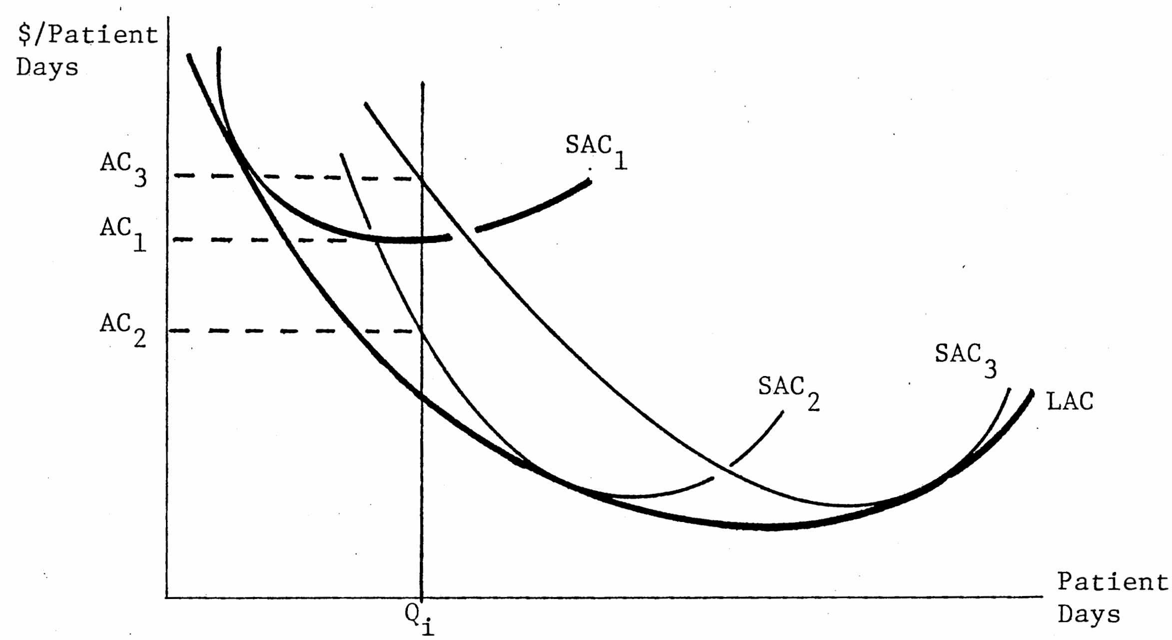


Figure 6. Relationships of Expansions in Beds to Hospital Average Costs

For example, the different changes in cost can be shown by initially assuming that the ith hospital is operating along SAC_1, producing Q_i days of patient care each day, with average cost of AC_1. When additional beds are added to the hospital, i.e., scale is expanded, such that the hospital is operating along SAC_2, average costs in the very short run would fall to AC_2. If, however, the ith hospital added twice as many beds such that it was operating along SAC_3, average costs would, ceteris paribus, rise to AC_3.

The short-run effect of an expansion in beds on a hospital's average cost is thus a function of:

(1) the number of beds added by expansion;

(2) the size of the expansion relative to the original size of the hospital in terms of beds; and

(3) the level of output and utilization in the hospital in terms of relative position along the short- and long-run average cost curves for the hospital.

These considerations make up the central interest of this study. Does the sheer number of beds added by expansion affect costs in the hospital over time? As well, does the relative size of an expansion in beds affect costs? A priori, it would be expected that each additional bed added by expansion would lower average cost for the range of less-than-superlarge hospitals which characterize most midwest hospitals. This is consistent with Feldstein's a priori expectations.[32] This does, however, run counter to the implicit assumption of the expansion regulation process, since the control of the number of beds added by hospitals is thought to lower costs.

It would also seem, ceteris paribus, that relatively large expansions would tend to raise average costs over time. This was true in Figure 6 and would be consistent with the notion that the larger the "shock" of an expansion upon a hospital, the greater the impact upon costs.

These and other relations are drawn more fully in the discussion of the conceptual model of hospital cost change over time which is presented in Chapter IV. In that discussion, some characteristics of 39 Wisconsin, Iowa, and Minnesota hospitals which expanded beds in 1971 are presented. Most importantly, estimates of the effects of bed expansions on costs are presented in the empirical analysis of Chapter V.

While an expansion in beds is translated into costs through shifts in the short-run average cost curve along the existing long-run average cost curve, expansions in facilities affect both short- and long-run average cost curves in the hospital.

Expansion of Facilities

A less commonly considered expansion in the hospital is the one which adds a hospital facility such as an open heart surgery ward or a renal dialysis unit to a hospital's inventory of facilities. Such expansions are often expensive in and of themselves while they seldom directly require new beds in the hospital.

Facility expansions most often change the product of a hospital rather than the scale of the hospital. Thus, cost curves associated with a hospital before and after an expansion of this nature are actually comparing two different products. Figure 7 shows how an expansion of facilities may shift both the long- and short-run average cost curves for the hospital.

For example, in the case of Figure 7, the hospital before expansion is providing x_i patient days of general patient care. This care consists of basic health maintenance procedures such as food and "hotel" types of services, and diagnostic procedures, but no active therapeutic procedures such as renal dialysis or other complex medical treatments. By the addition of a complex facility such as intensive cardiac care treatment, for example, the hospital is supplying x_i patient days of basic and complex hospital care. The two long-run average cost curves in the figure reflect the cost conditions in the hospital before and after the expansion of the complex facility.

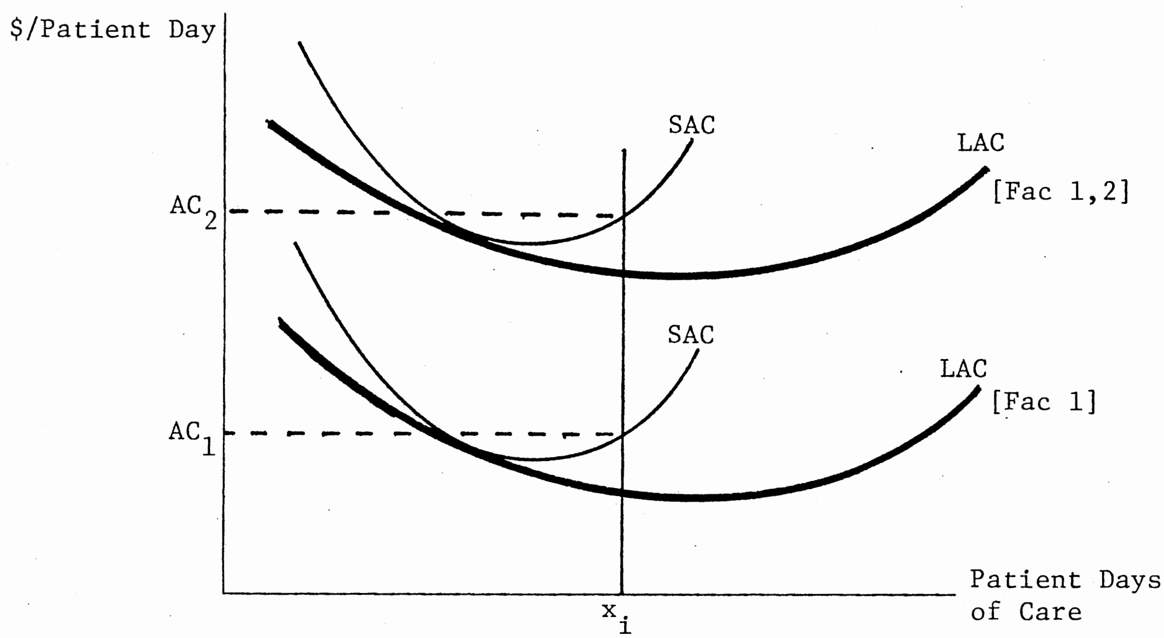
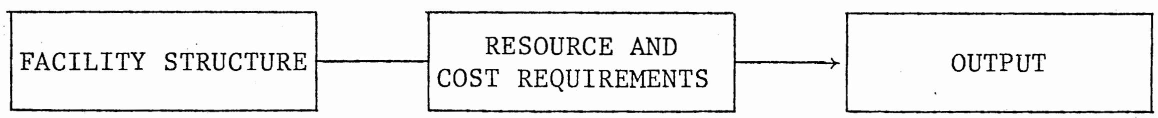


Figure 7. Relationship of Expansion in Facilities to Hospital Average Costs

The various facilities available in a particular hospital can be characterized by the term "facility structure." If a hospital has facilities which can render only the most simple of diagnostic care, the hospital's facility structure might be characterized as "basic." If a hospital also has facilities which will render some therapeutic care, the facility structure may be represented by "quality enhancing." Berry has broken the various types of hospital facilities and services into the five groups: basic, quality enhancing, complex, community, and special.[33] Figure 8 is an illustration of how hospital facility structure is associated with different hospital output compositions. The important implication of both the illustration and the concept of facility structure is that facility structure limits hospital output--complex care cannot be rendered without complex facilities.



Community and special facilities	Small	Preventive Care
Basic facilities	Small	Diagnostic
Quality-enhancing facilities	Greater	Diagnostic and therapeutic-partial
Complex facilities	Greatest	Diagnostic and therapeutic-complete

Figure 8. Association Between Hospital Facility Structure and Hospital Output

Changes in a hospital's facility structure by expansion thus affect costs by changing the nature of the product and of the cost conditions in the hospital. The effects of an expansion in facilities upon costs can therefore be stated as a function of the complexity of the facility added, both in absolute terms and relative to the existing facility structure in the hospital. The rather intuitive a priori expectation concerning facility expansions is that the more complex the facility, the greater the impact upon costs over time, and, the greater the contrast between the complexity of facilities added by expansion and that of existing facilities, the greater the impact upon costs. Each of these hypothesized relationships implies a direct positive relationship between the complexity of a facility and the upward shift in the hospital's cost curves. The more basic hospital facilities shift the cost curves upward slightly, while complex services bring about major shifts in the average cost curves.

A major problem in measuring the impact of facility expansions upon costs over time is in measuring the complexity of facilities; that is, in quantifying the complexity and costliness of various hospital facilities. This problem is addressed in Chapter IV, where the conceptual model of cost changes over time is developed. At the same time, characteristics of 68 Wisconsin, Iowa, and Minnesota hospitals which expanded facilities in 1971 are presented.

The regulation predicament of the health planner is no less troublesome at this point. Observed hospital cost increases, to the extent that they are (theoretically) tied to expansions in beds or facilities, are the result of shifting cost curves. But how can the planner use this information to regulate hospital costs? The following section describes the application of the preceding concepts in the effort to control costs through the regulation of hospital expansions.

Cost Control through Regulation of Hospital Expansions

One of the most important questions facing health planners in their attempt to rationally regulate hospital costs through expansion regulation is which proposed expansions to approve and which to discourage.

The assumption implicit in expansion regulation is that expansions in hospital beds or facilities today systematically affect costs in some later period. But which facilities add the most to costs? Can beds be added more easily in small hospitals than large, or do beds have a general effect?

The health planner is interested in a general explanatory model such as:

$$AC_{it+1} = C + \infty(\text{BEDS EX}_{it}) + \rho(\text{FACS EX}_{it}) + \theta(\text{OTHER}_{it}). \qquad (2)$$

Here, costs in a future period are a function of new beds and facilities added (BEDS EX and FACS EX) in the present time period plus all the interactions of the expansions with other parameters. The planner realizes that there are also certain parameters which directly affect costs in the hospital but which do not vary substantially over time. These parameters are embodied in the constant C of Equation (2). It is also apparent that there are other factors at work in raising hospital costs over time (OTHER) and that these factors must also be taken into consideration.[34]

If the elements of Equation (2) were known, the regulation process would be relatively straightforward. There are two general steps in this process.

The first step is needs assessment. In this step, commonly accepted guidelins are applied to the health and demographic characteristics of a region. For example, the bed need formula used for most states due to the Hill-Burton hospital construction program is:

a. The current service area use rate (total [current] patient days of hospital service in the area divided by the [current] population of the area) is multiplied by the projected (future) area population and divided by 365 to produce the projected average daily census of the area.

b. The projected average daily census is then divided by .85 (occupancy factor), and an additional 10 beds is added to the result, thereby producing the number of general hospital beds needed in the service area by [the future year].[35]

From assessments such as this, it is possible to determine how many beds (if any) and which kinds of facilities are "needed" in the region.

Secondly, and the step which has caused the greatest difficulty for the regulation process, a determination is made as to which hospitals are to be eligible for the various types of expansions needed. Employing Equation (2), the effects upon costs of adding the required number of beds throughout the region can be ascertained by applying the equation to each hospital in the region. The hospital(s) with the least impact from adding the needed beds would be eligible for future beds expansion. In more sophisticated eligibility determination models, linear programming techniques may be employed.

The problem of changing hospital output which plagues most hospital cost studies is not a problem in the regulation process. It is known that the addition of a particular facility is going to change the nature of output throughout the region. The only question for the expansion regulation process is where this facility can be placed within the region so as to minimize the impact upon costs of the increment to output. Again, the application of Equation (2) to each of the hospitals within the region should address this question.

There are obviously several other considerations which must be included in any analysis of a proposed expansion. These include the cost of time for people in travel, the risk to life in not having all facilities immediately available, and energy consumption patterns of the health delivery system. The purpose of this study is to develop a close approximation of Equation (2). If this can be accomplished, the tradeoffs necessitated by the presence of other considerations can explicitly be made.

Summary

This chapter has presented the "principles of production" in the short-term general hospital in some detail. This was done in order to develop the context within which hospital expansions possibly affect costs. It was shown that if, in fact, expansions of either beds or facilities affect costs, it is the result of shifts in the short- and long-run average cost curves vis-a-vis some level of output in the hospital. An expansion in the number of beds will shift the short-run average cost curve for the hospital outward along its long-run average cost schedule as the scale of plant in the hospital increases. An expansion of complex facilities will shift the cost curves for a hospital upward as the nature of its product becomes more heterogeneous.

The use of this information in the regulation process is fairly straightforward. The goal of expansion regulation is to minimize the costs of adding new beds and output-enhancing facilities.

FOOTNOTES

[1]In 1973, only 13 percent of the total nonfederal short-term general and other special hospitals were run for profit. Short-term general hospitals, in fact, make up one of the nation's largest industries. In 1973, over 440 million days of patient care were delivered by the hospital industry, resulting in total hospital expenditures of $36.3 billion. This represented 2.8 percent of the Gross National Product for that year. See American Hospital Association Hospital Statistics, 1974 (Chicago, 1974), Table 1 and text Table 1.

[2]Harry Greenfield, Hospital Efficiency and Public Policy (New York, 1973), p. 5.

[3]Hospital Statistics 1974, p. 15. "Community" hospitals are defined as all nonfederal short-term general and other special hospitals except psychiatric and tuberculosis hospitals, and hospital units of institutions such as prison and college infirmaries.

[4]Ibid.

[5]Ibid., p. 11.

[6]Full-time equivalent personnel is computed by adding one-half of the part-time personnel to the full-time personnel, exclusive of interns, residents, and trainees.

[7]Mary L. Ingbar and Lester Taylor, Hospital Costs in Massachusetts (Cambridge, Mass., 1968).

[8]See Karen Davis, Rising Hospital Costs: Possible Causes and Cures (Washington, D.C., 1973), Reprint 262, Table II.

[9]In 1973, total expenditures in U.S. community hospitals were $28.4 billion and payroll expenses $15.8 billion. See Hospital Statistics 1974, Text Table 11.

[10]For the two years between 1971 and 1973, the average rate of increase in payroll expenditures has been 10 percent while for nonpayroll expenses it has been 16.1 percent. Ibid.

[11]For two examples of the implications of the more complete specification, see Maw Lin Lee, "A Conspicuous Production Theory of Hospital Behavior," The Southern Economic Journal, XXXVIII (1971), pp. 48-58, and James R. Jeffers and Calvin D. Siebert, "Measurement of Hospital Cost

Variation: Case Mix, Service Intensity, and Input Productivity Factors," Health Services Research, IX (1974), pp. 293-307.

[12]Examples of this approach are Martin Feldstein, Economic Analysis for Health Service Efficiency (Chicago, 1968), and W. Carr and Paul Feldstein, "The Relationship of Cost to Hospital Size," Inquiry, IV (1967), pp. 45-65.

[13]Examples of this approach include Ralph Berry, "Product Heterogeneity and Hospital Cost Analysis," Inquiry, VII (1970), pp. 67-75, and Wayne Hales, "An Analysis of the Effects of Competitive Markets on Hospital Costs in Oklahoma" (unpub. Ph.D. dissertation, Oklahoma State University, 1974).

[14]Sylvester Berki, "The Pricing of Hospital Services," in Selma Mushkin (ed.), Public Prices for Public Products (Washington, D.C., 1972), pp. 353-356.

[15]Jeffers and Siebert, pp. 293-295.

[16]Hirsch Ruchlin and Irving Leveson, "Measuring Hospital Productivity," Health Services Research, IX (1974), pp. 308-309.

[17]Since AHA hospital data are used in this study, "patient days" reflects both inpatient and outpatient use of the hospital. See The American Hospital Association 1973 Guide to the Health Care Field (Chicago, 1973) for details of this measure.

[18]This is a generally accepted approach to measurement of hospital output for studies such as this. See Greenfield, p. 26.

[19]Richard Leftwich, The Price System and Resource Allocation (Hinsdale, Ill., 1973), p. 67.

[20]Refer to Leftwich, Chapter 9, and C. E. Ferguson, Microeconomic Theory (3rd ed., Homewood, Illinois, 1972), Chapter 7, for the complete development of short- and long-run cost curves.

[21]Leftwich, p. 170.

[22]Paul Feldstein, An Empirical Investigation of the Marginal Cost of Hospital Services, University of Chicago Studies in Hospital Administration, Graduate Program in Hospital Administration, 1961, pp. 51 and 63-64.

[23]Carr and Feldstein, pp. 45-65.

[24]Harold Cohen, "Hospital Cost Curves with Emphasis on Measuring Patient Care Output," in Herbert Klarman (ed.), Empirical Studies in Health Economics (Baltimore, 1970).

[25]Ralph Berry, "Returns to Scale in the Production of Hospital Services," Health Services Research, II (1967), pp. 123-139.

[26]Ingbar and Taylor.

[27]For a survey of how the homogeneous output measure kilowatt hour is used in analysis of this industry, see Lester Taylor, "The Demand for Electricity: A Survey," The Bell Journal of Economics, VI, (1975), pp. 74-110.

[28]For a discussion of the three technical problems of estimating hospital cost functions, see Judith and Lester Lave, "Hospital Cost Functions," American Economic Review, LX (1970), pp. 379-381.

[29]Ibid., p. 379.

[30]A. R. Somers, Hospital Regulation: The Dilemma of Public Policy (Princeton, N. J., 1969), p. 132.

[31]Ingbar, p. 339.

[32]Martin Feldstein, "Hospital Cost Inflation: A Study of Nonprofit Price Dynamics," American Economic Review, LXI (1971), p. 857.

[33]See Ralph Berry, "On Grouping Hospitals for Economic Analysis," Inquiry, X (1973), pp. 5-12.

[34]See Ingbar, Figure 1. I also appreciate the many discussions with Mr. Tim Tyson of the Wisconsin Department of Health and Social Services on this point.

[35]Wisconsin Department of Administration, Wisconsin State Plan for Hospitals and Medical Facilities, 1972-1973, 1972, pp. 3-5.

CHAPTER III

ALTERNATIVE EXPLANATIONS OF HOSPITAL COST INFLATION

Introduction

Hospital costs may rise for more reasons than just expansions in beds and facilities. Economists typically ascribe these various reasons to either the "demand-pull" or "cost-push" explanations of hospital cost inflation.[1]

An adequate job has been done in summarizing the major theories of hospital cost inflation--most notably the writing of Karen Davis.[2] The various theories can be classified into the two broad groups suggested above as shown in Table IV. Here, a third category is also included to allow for theories of inflation which do not clearly fit into either the "demand-pull" or "cost-push" classifications. The purpose of this chapter is to review relevant empirical studies which have tended to either support or question each of the theories. This review will highlight the array of variables which have been used in previous studies to capture the essence of the various theories. In subsequent chapters, this collection of variables will be useful in developing conceptual and empirical models of cost inflation over time. To avoid redundancy of other literature, a detailed description of each of the theories identified in Table IV will not be contained in this review.[3]

TABLE IV

ALTERNATIVE THEORIES OF HOSPITAL COST INFLATION[3]

Demand-Pull Theories	Cost-Push Theories
Demand caused by patients	Wasteful capital expenditures
Demand caused by physicians and other monopolists	Labor induced
	Cost reimbursement schemes
	Excessive hospital utilization
	Short-run constraints on capacity
	Inefficient sized hospitals

Other Theories
Advances in medical technology
Expansion in scope of hospital services
Review pressure constraint

Cost-Push Theories of Hospital Inflation

Cost-push inflation theories suggest that hospital costs are rising rapidly because, simply, the costs of producing hospital care are rising rapidly. The factor most often pointed out as the possible culprit in cost-push inflation is labor, since payroll costs are over one-half of hospital operating costs.[4]

Lave and Lave postulated that urban wage rates have risen relative to rural wage rates and that thus cost inflation would be positively affected by the urban location of a hospital. They found this relation statistically insignificant, however, upon testing and concluded that "...there is no conclusive evidence for our conjecture that rural hospitals probably experienced a lower rate of cost inflation than urban hospitals."[5] Pettengill also suspected this relationship; however, he was only able to support his hypothesis with descriptive evidence.[6]

Jeffers and Siebert also conduct a very limited test of the effect of rising factor input prices on costs per case. In examining three Connecticut short-term general hospitals, they found that rising input prices accounted for nearly eighty percent of the net increase in costs per case between 1960 and 1970.[7] While not strictly confined to the labor aspects of cost-push inflation, the two authors assumed, as did M. Feldstein, that labor constituted sixty-three percent of hospital costs.

Davis and Salkever provide possibly the best tests of the labor cost-push theory of cost inflation. Davis conducted pooled cross-section, time series regressions on 1965, 1967 and 1968 U.S. hospital information. She found that a ten percent increase in the wage rate led to an eight to nine percent increase in average costs. Sensing that this coefficient might be slightly high, Davis also suggested that other costs of hospital operation which also vary across geographic areas may have been picked up by the hospital's wage level.[8]

Salkever approached the labor cost-push aspects of cost inflation slightly differently than Davis. Rather than assuming wages in the hospital affected average cost, Salkever hypothesized that wages in a county's service industry most directly affected average cost in the hospital. This relationship was thought to express the effects of the local labor market conditions upon the hospital's cost structure. In ten different regression equations, Salkever found the service industry wage variable to be statistically significant once, and very close to significant at the (.05 level) four times. In each of these cases, a one percent change in local service wages was thought to lead to approximately a 0.04 percent increase in average costs.[9]

It should be said in passing before discussing other cost-push theories that M. Feldstein has suggested, although not tested, that two facets of labor which could place pressure on costs are the number of employees used per patient day and the average wage rate.[10]

But there are other factors than labor which can contribute to cost-push hospital inflation. Lave and Lave suggest that there may be some simultaneous cost pressures and relief resulting from the size of a hospital. On the one hand, they suggest that large hospitals have more specialized services and that the costs of these services have been rising more rapidly than other costs. On the other hand, they suggest that large hospitals are more efficient than smaller hospitals and thus they well may have smaller cost increases than the latter. Their empirical test found the regression coefficient for the log of beds to be significant; however, it was very low (approximately 0.02).[11] Thus, it is very difficult to determine whether the two effects have little effect on cost increases or approximately counteracting effects.

The methods by which hospitals are reimbursed by third party insurers, such as Blue Cross, have also been postulated to adversely affect costs in the hospital. Under this theory there is little incentive to economize since new hospital costs can be almost entirely passed on to third part insurers. Thus, it is suggested that hospitals have no reason to ration expenditures on equipment or supplies or on salaries.

Pauly and Drake looked at hospital data in Illinois, Indiana, Michigan and Wisconsin for 1966 and found that costs did not appear to differ between states with cost-reimbursed schemes and charge-reimbursed schemes.[12] Davis examined this same question using different data and a different measure[13] of insurance coverage and found also that cost-reimbursement schemes seem to have little systematic effect on average costs in the hospital.[14]

This cost-reimbursement argument is not only supply oriented, but also affects the demand for hospital care as well. This will be noted again under the subsequent discussion of the demand-pull theories of hospital cost inflation.

The remaining theories of cost-push hospital inflation have received very little empirical attention. Hospital utilization was examined by Lave and Lave, but no significant relations were found.[15] Wasteful capital expenditures, short-run constraints on hospital utilization, and the inefficiency of small hospitals have received little more than discussion in the cost inflation literature.[16]

Demand-Pull Theories of Hospital Inflation

Demand-pull inflation theories suggest that hospital costs are rising rapidly because consumers of hospital care are demanding more of the hospital system than the system is capable of providing. The only alternatives for the hospital are to try and meet this demand at any cost or to ration available hospital services via the price mechanism. Both alternatives mean rising costs in the hospital industry.

Demand-pull pressures on hospital costs are usually considered to rise from two sources: either patient consumers of hospital care or physician consumers of hospital care. The flow of hospital and physician resources to the patient/physician consumer is depicted in Figure 9.

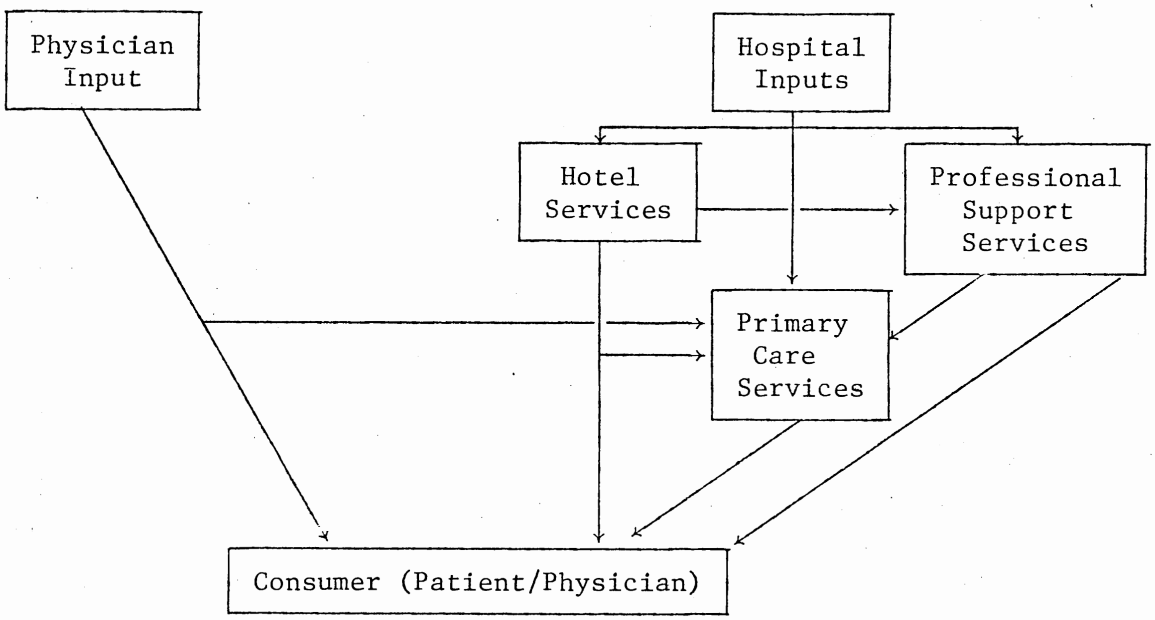


Figure 9. Flow of Resources to the Patient/ Physician Consumer

Here it can first be noted that the physician is both a health resource and a consumer. It would be reasonable to expect under this situation that physicians may increase the demand for hospital inputs by acting in their capacity as a consumer of hospitals' services. Or, it would also be reasonable under this situation to expect doctors to lessen the demand for hospital resources as they act in their capacity as medical input--in their own office.

Secondly, a distinct consumption pattern is suggested in Figure 9. Some hospital services, such as food and lodging, are consumed completely by the patient. Some hospital services are consumed completely by the physician, such as laboratory tests. And some hospital services, such as the surgery units, are consumed jointly by the physician and the patient. This concept of consumption is not too dissimilar from the models presented by Bailey,[17] Pauly and Redisch,[18] and Newhouse.[19]

Insurance coverage seems to be one element of patient-originated demand-pull inflation which receives considerable attention. Increased insurance coverage is thought to increase demand for hospital services by lowering the effective price to the consumer. Martin Feldstein has found that fifteen percent of recent rises in hospital prices have been due to rising insurance coverage.[20] Salkever found a one percent increase in the percentage of people not having four different measures of insurance led to a 0.12 to 0.26 percent decrease in average costs over time.[21] That is, the less insurance people had, the smaller the increase in the local hospital's average cost. These findings tend to substantiate Kaitz's findings "...that the cost-based third party payment system has, all other forces being constant, been a key force motivating the steady and inordinate increase in hospital costs in the past twenty years."[22]

Rising personal incomes may also be an element of patient-originated demand-pull cost inflation. As incomes rise, it can be argued that purchases of hospital services will rise if this is a normal good. This might especially be the case if higher incomes make the opportunity cost of illness relatively high and if the higher education levels associated with higher incomes make people more aware of the workings of the health care system.

Feldstein found that rising incomes accounted for nearly thirteen percent of rising hospital prices in the period 1958 to 1967.[23] Pettengill also found, using descriptive data, that variations in per capita incomes affect hospital revenues.[24] Salkever, however, found that per capita income was never statistically significant in explaining 1961 to 1967 New York hospital cost inflation.[25]

The only other test of patient-related inflation variables has been that of Salkever on demographic variables. He found that population in a hospital's market area is significant in explaining hospital cost increases as market demand increases; however, the effect is very small. He also found that population density (another market measure) and average household size (a measure of the health characteristics of the population) contribute little systematically to explain cost increases over time. Thus, the trut health characteristics of the population appear to exert very little influence on hospital costs over time.[26]

Much of the discussion concerning demand-pull cost inflation has centered around that generated by the physician. Here it is either thought that the physician acts as a substitute to hospital care and thereby reduces demand upon the hospital's resources or, as previously suggested in Figure 9, acts as the leading consumer of the hospital's output. Concerning the physician's role in the hospital, Kaitz indicates that the physician orders about eighty percent of the dollar value of services and supplies rendered each patient.[27]

Feldstein and Salkever handle this question differently. They both do, however, begin with the same hypothesis that hospital based or oriented physicians will increase demands upon the hospital and that non-hospital oriented physicians such as general practitioners will act as substitutes for hospital care. Feldstein found that as the proportion of general practitioners to the total number of physicians falls, price in the hospital rises. In agreement with his hypothesis, Feldstein estimated hospital prices to have risen by five percent due to the increasing proportion of hospital oriented physicians.[28] Salkever examined this question using two separate variables, total physicians per person and general practitioners per person, and found only the former variable to be statistically significant. Both coefficients were of the hypothesized sign; however, once again the effect of the total physician per person variable on average costs was very small.[29]

Other Theories of Hospital Inflation

Not all inflation theories fit under the two preceding categories and not all theories pertain to increases in hospital costs.

Lave and Lave have discussed a possible constraint to the process of hospital cost inflation which, if true, would tend to restrict the rise in costs in certain hospitals. They suggest that, ceteris paribus, hospitals with relatively high initial cost will tend to experience a slower rate of cost increase over time. This is due to the pressure exerted by third party insurers, citizens and conscientious doctors on the hospital's behavior. This condition may also exist as hospitals strive to bring their costs in line with other hospitals. Lave and Lave's empirical test of this hypothesis on Pennsylvania hospitals found the variable to be significant and negative (as hypothesized) in the western parts of Pennsylvania where effective pressure was thought to exist on hospitals and insignificant in an area where review pressure was thought to be less.[30]

The other two "other" theories in Table IV, while not tested, are important alternatives to all of the theories discussed on the preceding pages. Both the "advanced medical technology" and the "expanded scope" theories of cost inflation suggest that what one is actually observing in rising hospital costs is changing--improving--hospital output. In the first theory, existing services are getting better, such as the dramatic improvements in auto-analyzer laboratory equipment, and new services are coming into being. Under the second theory, costs are increasing as the hospital adds functions which previously existed in other sectors, e.g., inpatient psychiatric treatment. In both theories, the basic thesis is that "you get what you pay for."

Summary

This chapter has examined the empirical tests of several theories of hospital cost inflation. The examination has not exhausted the list of possible explanations of hospital cost inflation and, conversely, the word "theory" has been used in several places where "casual observation" might be more appropriate.

The list of variables used in previous hospital cost inflation (or related) studies is summarized in Table V. A general observation of the various theories of cost inflation suggests that many of the explanations have not yet been well tested. The impact of hospital expansions upon hospital costs, which is the subject of this study, has not been directly addressed by previous empirical work.

To the extent possible, the alternative explanations of hospital cost inflation must be considered simultaneously with expansion-related inflation if the true relative significance of the latter is to be ascertained. This is true if for no other reason than statistical completeness in explaining the variation in cost increases among hospitals over time.[32] The conceptual model developed in the following chapter

TABLE V

VARIABLES USED IN EMPIRICAL TESTS OF COST INFLATION THEORIES

Theory/Variable	Study	Finding
Cost-push: labor		
Urban location	Lave & Lave	Insignificant
Urban location	Pettingill	Not tested
Input price index	Jeffers & Siebert	Positive and significant
Wage rate-hospital	Davis	Positive and significant
Wage rate-service industry	Salkever	Seldom significant; positive but small
Employees per patient day	M. Feldstein	Not tested
Wage rate-hospital	M. Feldstein	Not tested
Cost-push: non-labor		
Hospital size (beds)	Lave & Lave	Significant; positive but small
Presence of cost- or charge-reimbursed third party systems	Pauly & Drake	Insignificant
Blue Cross payment scheme	Davis	Insignificant
Utilization rate	Lave & Lave	Insignificant
Demand-pull: patient		
Blue Cross payments as % of total	M. Feldstein	Positive and significant
% not having insurance	Salkever	Negative and significant

TABLE V (Continued)

Theory/Variable	Study	Finding
Real per capita disposable income	M. Feldstein	Positive and significant
Per capita income	Salkever	Insignificant
Population	Salkever	Significant; positive but small
Population density	Salkever	Insignificant
Average household size	Salkever	Insignificant
Demand-pull: physician		
Ratio of general practitioners to total doctors	M. Feldstein	Negative and significant
Total physicians per person	Salkever	Insignificant
General practitioners per person	Salkever	Significant; negative but small
Other theories		
Initial costs	Lave & Lave	Negative and significant

will use many of the variables discussed in the preceding pages to incorporate the influence of factors other than expansion upon hospital costs over time.

FOOTNOTES

[1]Greenfield, p. 11.

[2]See Karen Davis and Richard Fosters, Community Hospitals: Inflation in the Pre-Medicaid Period, U.S. Department of Health, Education, and Welfare, Social Security Administration, Office of Research and Statistics, Research Report No. 41 (Washington, D.C., 1972), Chapter 1; Davis, Rising Hospital Costs; and Karen Davis, "Theories of Hospital Inflation: Some Empirical Evidence: The Journal of Human Resources, VIII (1973), pp. 181-201.

[3]The reader should see Davis and Fosters, Community Hospitals, Chapter 1, for a detailed discussion of most of the theories identified.

[4]Payroll expenses represented fifty-eight percent of total expenses in "non-federal short-term general and other special community" hospitals in 1971. See American Hospital Association Hospital Statistics, 1971 (Chicago, 1971), Table 1, pp. 12-13.

[5]Lave and Lave, "Hospital Cost Functions," pp. 386-387.

[6]Pettengill, p. 19.

[7]Jeffers and Siebert, pp. 303-305.

[8]Davis, "Theories of Hospital Inflation," p. 192.

[9]David Salkever, "A Microeconomic Study of Hospital Cost Inflation," Journal of Political Economy, LXXX (1972), pp. 1153-1156.

[10]Martin Feldstein, "Hospital Cost Inflation," p. 856.

[11]Lave and Lave, "Hospital Cost Functions," pp. 381 and 386.

[12]Mark Pauly and David Drake, "The Effect of Third Party Methods of Reimbursement on Hospital Performance," in Herbert Klarman (ed.), Empirical Studies, pp. 297-314.

[13]Pauly and Drake employed a zero-one dummy variable for hospitals with either cost-reimbursement or charge reimbursement, while Davis employed a continous measure of the proportion of a hospital's expenses covered by a cost-reimbursement plan.

[14]Davis, "Theories of Hospital Inflation," p. 190.

[15]Lave and Lave, "Hospital Cost Functions," p. 386, and Lave and Lave, "Estimated Cost Functions for Pennsylvania Hospitals," Inquiry, VII (1970), p. 9.

[16]Wasteful capital expenditures have been discussed by Burton Weisbrod, "Collective-Consumption Services of Individual Consumption Goods," Quarterly Journal of Economics, LXXVII (1964), pp. 471-477, and by Lee, pp. 48-58.

[17]Richard Bailey, "Economies of Scale in Medical Practice," in Herbert Klarman (ed.), Empirical Studies, pp. 255-273.

[18]Mark Pauly and Michael Redisch, "The Not-for-Profit Hospital as a Physician's Cooperative," American Economic Review, LXIII (1973), pp. 87-89.

[19]Joseph Newhouse, "A Model of Physician Pricing," Southern Economic Journal, XXXVII (1970), pp. 174-183.

[20]Martin Feldstein, "Hospital Cost Inflation," p. 869, Table 4.

[21]Salkever, p. 1156, Table 2.

[22]Edward Kaitz, Pricing Policy and Cost Behavior in the Hospital Industry (New York, 1968), p. v.

[23]Martin Feldstein, "Hospital Cost Inflation," p. 869, Table 4.

[24]Pettengill, p. 19.

[25]Salkever, p. 1156, Table 2.

[26]Ibid.

[27]Kaitz, Appendix C.

[28]Martin Feldstein, "Hospital Cost Inflation," p. 869, Table 4.

[29]Salkever, p. 1156, Table 2.

[30]Lave and Lave, "Estimated Cost Functions," pp. 6-9.

[31]See Greenfield, p. 23, and Jeffers and Siebert, p. 293, for other suggestions.

[32]See J. Johnston, Econometric Methods (2nd ed., New York, 1972), pp. 168-169.

CHAPTER IV

CONCEPTUAL MODEL OF HOSPITAL COST INFLATION

Introduction

The purpose of this chapter is to develop the basic model to be used in explaining the changes in a hospital's average cost over time. The model developed is very similar in form to the general explanatory model discussed in Chapter II so that its use may prove helpful to the health planner. The model is also constructed such that the concepts presented in Chapters II and III can be incorporated explicitly in the explanation of hospital cost changes over time.

Most of this chapter concentrates on the identification of specific variables with which to make the conceptual model complete. Within this discussion, considerable attention is given to the problem and process of measuring hospital expansions. After identifying each variable to be included in the conceptual model, the expected relationship between each variable and average hospital cost over time is suggested.

Conceptual Model of Hospital Cost Inflation

Hospital costs, at least theoretically, do not randomly fluctuate over time. The preceding two chapters have suggested that costs could change due to expansions in hospital scale and complexity or due to other forces, both external and internal to the hospital. What is needed is a general model which describes hospital cost change over time. This model, if it is to be useful for present purposes, should be very similar to the planning regulation model (Equation (2)) suggested in Chapter II.

The model developed in this study is composed of two broad conceptual elements. The first element assumes that there is an equilibrium level of average hospital cost in a particular time period which is determined by the interaction between the demand for hospital care and the supply conditions existing in a hospital during that time period. The second element assumes that costs change over time in hospitals because of the gap between actual and equilibrium average costs. Each of these elements is discussed in detail below.

The first element of the cost inflation model developed here combines information contained in three major hospital relationships into a reduced form equilibrium average cost equation. The three relationships involved are (1) demand for hospital care, (2) costs of producing that care, and (3) hospital price setting. The pattern of these relationships follows closely the theoretical developments of M. Feldstein and Salkever in their respective efforts to model the hospital industry and hospital cost inflation.[1]

Demand for hospital care can be conceived of in terms similar to the demand for other goods and services. The quantity of patient days of care demanded by hospital consumers is affected by the price of hospital treatment, the economic and physical well-being of the individuals using the hospital, and other factors such as the attitudes of local physicians and the insurance coverage of the individuals. Martin Feldstein, for example, has included the price of hospital care, income, the availability of hospital facilities and alternative sources of care, and general attitudes toward hospital care in his estimate of per capita demand for inpatient hospital care.[2] It can be assumed that the quantity of hospital care demanded will diminish with a rise in price, all other things (such as income) remaining constant. The general demand relationship can be stated as

$$Q_t = f(P_t, D_{jt}) \qquad j=1,2, \ldots m \tag{3}$$

where Q_t is the quantity of care demanded, P_t is the price of care, D_{jt} is a vector representing other parameters which affect demand (such as income), and t reflects observations in the current time period.

Although Equation (3) can generally be thought of as a demand function for hospital care, as Salkever points out, such a relationship in the hospital is more appropriately called a price-output or output-determination function.[3] This distinction will appear more clear after the discussion of hospital price setting.[4]

The discussion in Chapter II suggested that the quantity of care supplied by a hospital is governed by the supply conditions existing in the hospital. Thus, within its technological limits, the hospital attempts to meet all expressed demand, with its average cost varying as the level of output changes. This relationship can be stated as

$$AC_t = f(Q_t, S_{jt}) \qquad j=n,o, \ldots r \tag{4}$$

where AC_t is the average cost in the hospital, Q_t and t retain the same meaning, and S_{jt} represents a vector of supply parameters (such as variable inputs, their costs, utilization, etc.) which affect costs in the hospital.

Such a cost relationship is very similar to conditions existing in other regulated industries, such as electrical generation. In these industries "firms" do not find themselves in the position of adjusting output in response to changing prices, but rather find themselves minimizing costs for various externally imposed output levels.[5] Thus, if a certain number of people present themselves at the hospital door seeking care, the hospital, if technologically possible, renders the necessary care at the lowest possible cost.

These two relationships are brought together by the pricing behavior which hospitals follow. Martin Feldstein, in constructing his 12-equation model of the non-profit hospital industry, assumed a basic budget constraint for the hospital of

$$P_t = C_t - D_t$$

where P_t is average current price, C_t is the average cost per patient day, and D_t is the deficit per patient day which the hospital incurs.[6] Feldstein further notes that the size of deficit which is generally determined by the income from endowment and philanthropic donations is small and thus price in the non-profit hospital industry can be assumed very close to average cost. This condition is increasingly true as philanthropic grants are decreasing as a percentage of total non-profit hospital capital funds.[7]

The present model similarly assumes that the hospital sets its price equal to average cost. More specifically, that price in the present period is set equal to average cost at the end of the previous period. This relationship can be expressed as

$$P_t = AC_{t-1} \qquad (5)$$

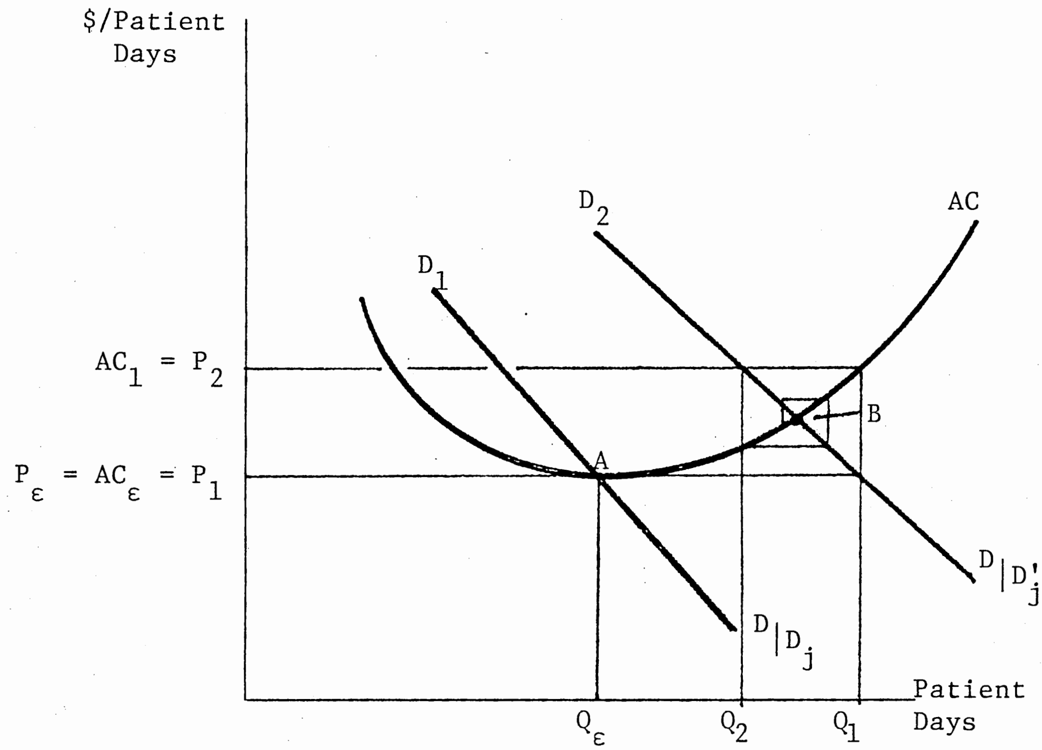
where all symbols retain their previous meanings and t-1 represents observations in the previous time period.

Several factors suggest that an average cost pricing assumption may not be inappropriate in the non-profit short-term general hospital industry. Paul Feldstein and Gorman best summarize some of the major barriers to the use of marginalist principles in the hospital industry.[8] Some of the most important considerations they discuss include (1) the uncertain nature of hospital demand, (2) the relationship between inpatient and outpatient care, (3) the link between physician income and hospital status, (4) social aspects of the peak-load problem in the hospital, and (5) the difference between private and public efficiency measures. Each of these factors, and others that the authors develop, suggest that average cost pricing behavior may well be the general pattern in this industry.

The process at work in the model developed here begins by the hospital setting price equal to its known average cost, such as in Equation (5). Once price is determined, quantity demanded (and thus consumed in this model) is demand determined as in Equation (3)--thus the nomenclature "output determination function." The hospital facing the now determined quantity of demand can meet this need at the lowest possible cost per Equation (4).

The dynamics of the model can be seen by juxtaposing the demand and cost functions as in Figure 10. Here, suppose as in Case I that the hospital is initially in equilibrium at Point A with price P_ε just equaling average cost AC_ε for the Q_ε level of output. As demand shifts

CASE I



CASE II

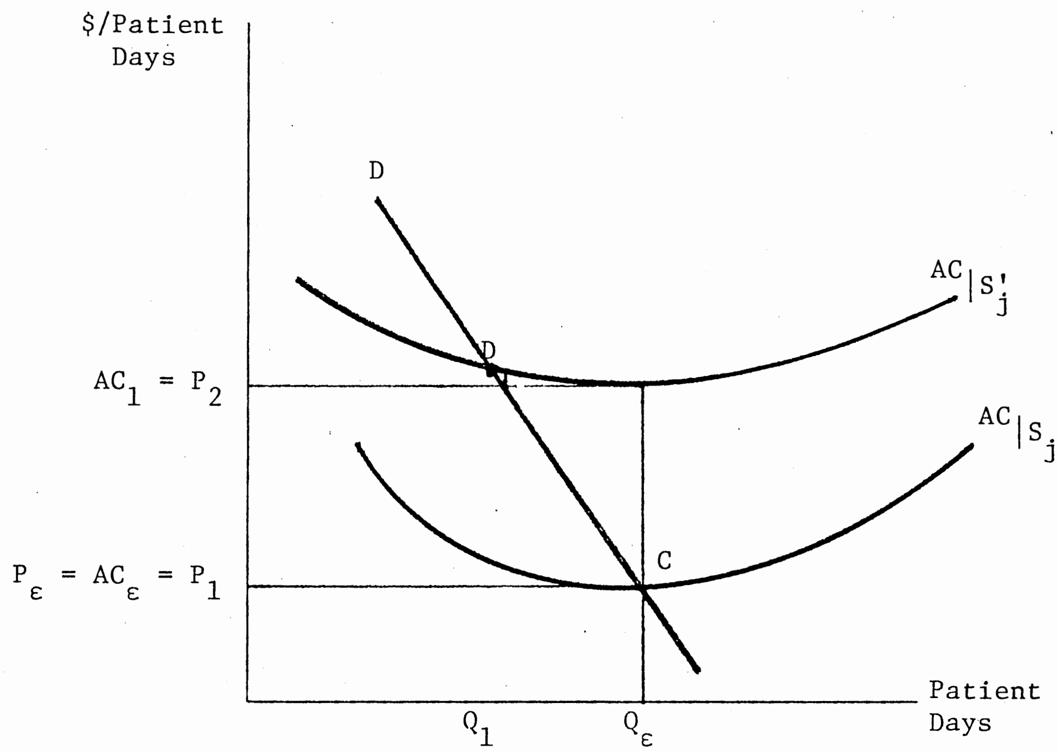


Figure 10. Equilibrium Average Cost and the Demand for and Supply of Hospital Care

outward due to demand parameter (D_j) shifts such as rising incomes, price remains at previous average cost levels, thus producing a quantity demanded equal to Q_1 at the new demand schedule. To produce this quantity of care at minimum cost possible, the hospital incurs an average cost equal to AC_1, which is also the level at which the hospital sets price in the subsequent period. This process is repeated until a new equilibrium average cost (and price and output) is (are) reached at Point B.

The same process is at work as changing supply parameters affect the cost function. Again, as shown in Case II of Figure 10, average costs change from Point C to Point D whereupon they remain unless further disturbed by changing supply or demand parameters.

The pattern of changing supply and demand parameters and their effects upon equilibrium average costs and output levels is very similar to the suggestion of Carr and P. Feldstein that:

> Shifts in the size and distribution of the population, variations in the prevalence of disease, disability and pregnancy, and changes in medical technology continously alter the optimum number, size, and geographic distribution of hospitals.[9]

Equilibrium average cost in the hospital is determined by the relative positions of the output-determination and cost functions. Movement along either of the existing functions is determined by the level of price or average cost, while the position of the functions in the conceptual x-y coordinates is determined by the levels of the various supply and demand parameters.[10] Thus, equilibrium average cost in the hospital, which can be denoted by AC_t^*, can be considered a function of the parameters which affect the position of the output-determination and cost functions. This relationship can be stated as

$$AC_t^* = f(D_1, D_2, \ldots D_m, S_n, S_o, \ldots S_r) \quad (6)$$

where the D_j and S_j remain the supply and demand parameters which affect the hospital.

The second broad conceptual element of the present model builds upon the fact that, during any time period, price may not equal average cost and that a subsequent adjustment will take place. To incorporate the adjustment aspects of cost change over time, a partial adjustment model is employed. Specifically, the difference between average cost in the present and a previous time period is assumed to be a proportion of the gap between equilibrium average cost in the present period and actual average cost in the previous period. This relationship can be stated as

$$AC_t - AC_{t-1} = \lambda(AC_t^* - AC_{t-1}) \quad (7)$$

where all variables retain their previous meaning and λ represents the "speed of adjustment" in hospital cost changes.

The speed of adjustment coefficient reflects the fact that the gap between equilibrium average cost at the end of the period and actual average cost at the beginning of the period may not be completely closed during the period. The speed by which a hospital adjusts to the gap between equilibrium and actual cost may lie between zero and one, i.e., $0 \leq \lambda \leq 1$. An adjustment coefficient close to zero means that very little of the gap is closed during the period. A coefficient close to one means that a large portion of the average cost gap is closed. The failure to achieve instantaneous adjustment to the equilibrium level of average cost in each hospital is not only due to the pricing policies followed in non-profit hospitals but could also partly be due to cost review pressure from third party insurer groups, from social pressure of the public at large, or from the reaction of nearby hospitals to changes in a particular hospital's demand or supply conditions.

While simple, the conceptual model developed here in Equations (6) and (7) relates the change in a hospital's average cost to equilibrium average cost for that hospital and the level of costs in the hospital in the previous period. The fact that cost changes may not be instantaneous in any one time period is also included.

Unfortunately, one of the key variables in the model, AC^*_t, can be neither measured nor observed. Equilibrium average cost in the hospital is a theoretical construct which, as postulated in Equation (6), is determined by the supply and demand conditions for the hospital. The remainder of this chapter is devoted to identifying potentially important variables of both supply and demand for hospital care--these are the S_js and D_js of Equation (6). The precise specification of the statistical model used to estimate Equation (7) is carried out in Chapter V.

Determinants of the Supply of Hospital Care and Their Effect Upon Costs

Chapter II suggested that an expansion of a hospital's beds or facilities may affect costs by either shifting the hospital's short-run average cost curve along its existing long-run average cost curve or by changing the nature of the hospital's output and its associated long-run cost schedule. The present search is for variables which capture these effects, with special emphasis given to the measurement of the variables.

Subsequent discussion will search for variables which capture the effects of other supply-related determinants which also affect a hospital's costs.

Expansion of Beds

The measurement of an expansion in beds is relatively quite easy. A hospital adds one bed, or six beds, or 20 beds, for example, and each bed is about equally expensive. Therefore, a variable, BEDX, which is the number of beds added by expansion, can be used to capture the effect of new beds upon costs over time.

But, as suggested in Chapter II, this variable alone does not capture the "pure" effect of new beds upon costs. One can even postulate that, without taking other factors into account, a priori judgments about the direction of the impacts of new beds upon costs cannot be made. Thus, several adjusting variables must be included.

The first of these adjustments is for the relative position of the hospital along its short-run average cost curve. This can be measured by OCC, which is the annual average occupancy rate of the hospital at the end of the period of observation. Ceteris paribus, it would be expected that new beds would add more to costs in hospitals with high occupancy rates as economies of scale are played out.

Secondly, the relative position of the hospital along its long-run average cost curve must be taken into account. This can be measured by PATDAYS, the total number of patient-days of care rendered in the hospital during the last year of observation. In this case, ceteris paribus, long-run economies of scale may well allow new beds to be added to very active hospitals with reduced impacts on costs over time. To the extent that the hospital has a U-shaped average cost curve, an associated variable, PDSQ, which is PATDAYS squared, must also be included. At high levels of output, diseconomies of scale should set in and this variable will override the expected negative effect of PATDAYS on costs. Thus, PDSQ is expected to be positively related to costs over time.

The last adjustment is for the shift in the short-run average cost curve relative to itself. The more beds added to a hospital relative to the existing number of beds, ceteris paribus, the more traumatic the impact upon hospital costs. This can be measured by the variable RBEDX, which is the ratio of new beds added by expansion to total beds in the hospital.

Since "beds added by expansion" is one of the central concerns of this study, it is useful to discuss the characteristics of the four variables above in the 39 Wisconsin, Iowa, and Minnesota short-term general hospitals which expanded beds in 1971. A description of the hospitals included in this study is deferred until Chapter V. The major characteristics of these variables are:

(1) The average expansion in beds among this group of hospitals was 22.4 beds, with the range running from three to 62 beds. Sixty-eight percent of the expansions fell between seven beds and 38 beds.

(2) Utilization in the 39 hospitals averaged 70.4 percent in 1973. This is only slightly lower than the average for all similar hospitals in the three states as a whole, which is 70.5 percent.

(3) Large hospitals tend to add fewer beds in proportion to their size than do small hospitals. The correlation between "new beds to total beds" and original size is -0.57 (significant at the 0.01 level).

This is consistent with Ginsburg's finding that large hospitals do not build any more beds than small hospitals.[11]

(4) The level of output as measured by patient days of care tends to have little systematic variance with the size of expansion. The correlation between "patient days" and beds added by expansion is both small, 0.01, and not statistically different from 0 (with a t statistic of only 0.06).

Expansion of Facilities

The measurement of an expansion in facilities is considerably more difficult than the measurement of an expansion in beds. Some facilities such as blood banks are quite simple in that they require a small amount of space, utilize conventional (refrigeration) equipment, and can be staffed by a few relatively low-skilled workers. Other facilities, on the other hand, such as renal dialysis, may require considerable space and complicated equipment, and must be staffed by highly trained technicians. The impact of each individual hospital facility upon cost reflects a similar variability. The task in this study is to identify existing and expanded facilities such that these elements of the hospital can be related to changes in costs over time.

Previous attempts at quantifying the facility structure of a hospital have already been discussed in the definition of hospital output contained in Chapter II. These efforts consisted largely of either (1) separating the hospitals under analysis into groups with similar facilities, or (2) including a series of independent dummy variables in the analysis representing either groups of facilities or individual facilities. Examples of the first type of adjustment are found in Carr and

Feldstein,[12] Berry,[13] and Francisco,[14] where the various hospitals being studied are stratified into either five, 25, or 40 groups (respectively) with similar facility structures. Examples of the latter approach to measuring hospital facilities are found in Berry[15] and Hales.[16] Here, 27 and 34 dummy independent variables (respectively) are added to the analysis to represent the "availability of facilities and services."[17]

Neither of these approaches fits the needs of the present study especially well. Classifying hospitals into groups suffers in the case where a hospital adds a facility such that it moves into another group. The latter approach of a series of dummy variables attests only to the presence or absence of the identified facilities, and information about the relative complexity of the various facilities is not included in the analysis. Francisco also argues that the latter approach is statistically very "matrix-consuming."[18]

A desirable measure of hospital facilities for the purposes of examining the effects of facility expansions upon costs would be one that reflects the relative complexity of each facility offered by a hospital, complexity meaning in this case the amount of resources, both fixed and variable, required to support a facility. A "complex" facility would require a significant amount of supporting resources and would thus reasonably have a major impact upon a hospital's costs.

This notion of complexity has previously been identified by Pettengill in his analysis of hospital financial positions in that the "range and complexity of services has a strong influence on unit costs through input requirements both for personnel and for plant and equipment."[19] Berry likewise concluded that, "Complexity contributes to cost, and an inappropriate quantity of complexity could add a significant amount to the nation's total bill for hospital services."[20] Neither author, however, was satisfactorily able to define hospital complexity.

It would also be desirable for a measure of hospital facilities to be continuous rather than dichotomous. This is so because (1) some facilities have a greater impact upon costs than do others and thus should receive greater weight[21]--a dichotomous variable assigns equal weight to each facility present in a hospital, and (2) a continuous measurement of facilities allows a composite picture to be painted of a hospital's facility structure or to changes in that structure. That is, values assigned to individual facilities can be added to determine a composite value for a hospital's existing facility structure or for an expansion of that structure.

The central place theories of regional science are a starting point for dealing with the measurement of facility complexity. Berry and Garrison noted in 1958 that two concepts, "population thresholds" and market "range," largely determine the spatial distribution of tertiary economic activities such as health care.[22] Under this theory, a good cannot be provided unless there is a population base, or threshold, large enough to support the provision of the good profitably. The range, on the other hand, is the "maximum distance the average customer is willing to travel to procure a certain good."[23] Thus, one is likely to find a drug store in every town but a computer company in only the largest population centers.

The basic notion of this concept applied to hospital facilities is contained in Figure 11. Costs, it is postulated, rise with the complexity of the facility and thus the number of people which would be required to economically support a facility also rises. From a regional science perspective, Figure 11 suggests which hospital facilities are likely to be found in various regions or hospital service areas. For example, a service area with 100 residents is likely to find a hospital with only a blood bank (in the context of Figure 11). A region with 1,000 residents is likely to find a hospital with both a blood bank and an open heart surgery unit.

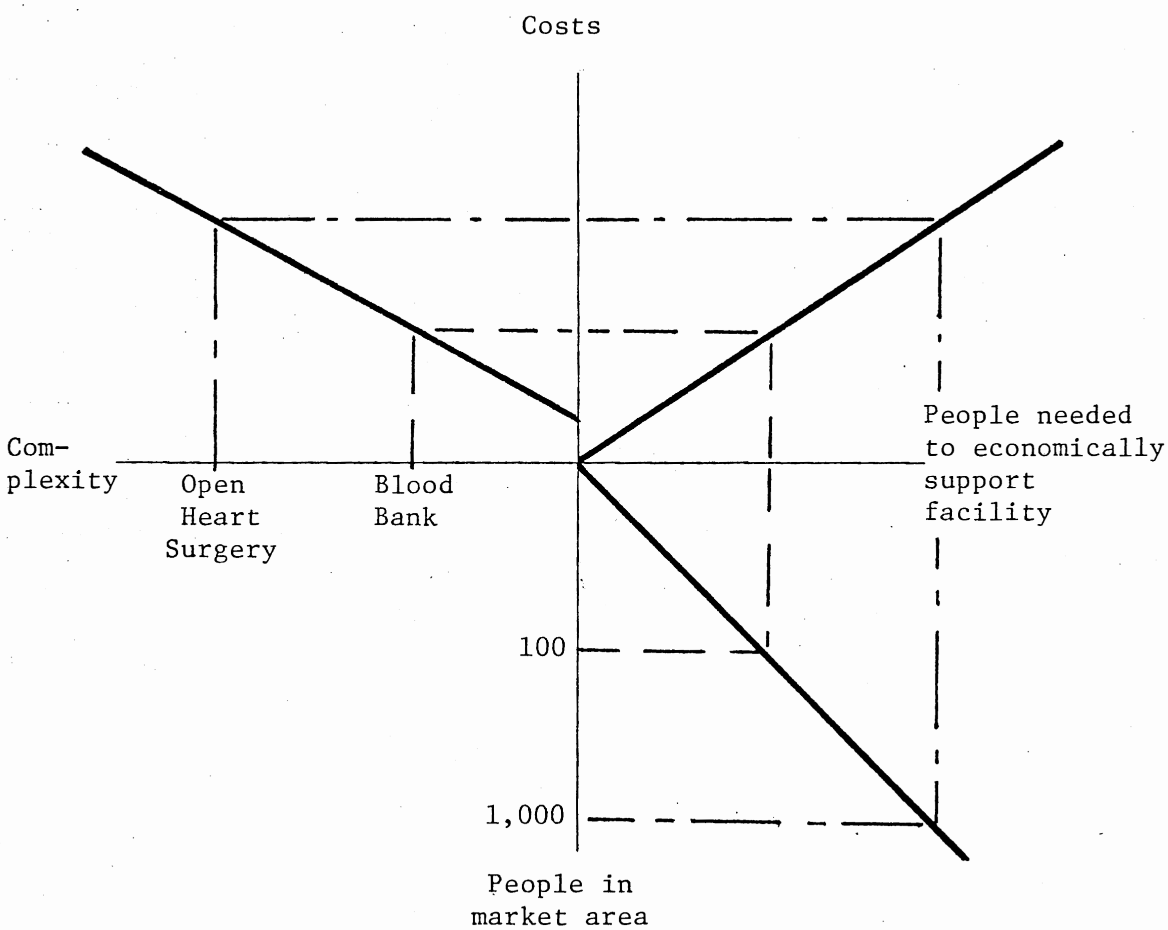


Figure 11. Role of Complexity in Rationing Hospital Facilities over Space

Berry has observed this hierarchy of function in his analysis of U.S. short-term hospitals.[24] He found that there are roughly five facilities which are "basic" to hospitals. These facilities are clinical laboratory, emergency room, operating room, delivery room, and X-ray and diagnostic facilities. After these facilities are established in a hospital, there is a tendency to first add facilities which enhance the quality of the basic services, such as a blood bank, and then to add facilities which expand the complexity of the hospital, such as an intensive care unit.

To quantify the facilities existing in, and/or added by, the hospitals examined in this study, Berry's initial procedures for classifying hospitals have been followed. Under this procedure, the number of short-term general hospitals in Wisconsin, Iowa, and Minnesota which had a particular facility in 1971 was determined and then ranked in descending order. Only those facilities which are uniquely hospital functions are included in the list. Other facilities, such as pharmacy, which are found largely outside the hospital have been omitted.[25] Table VI shows the list of facilities counted and the number of hospitals having each facility.

One approach to developing an index of facility complexity is to simply assign some level of mathematical importance to each facility according to its relative presence among all hospitals. The only previous effort to construct such an index was that of Roemer, Monstafa, and Hopkins in their development of a hospital "technological adequacy index." Here, the authors constructed a single index number to reflect the "presence or absence of numerous scientific features associated with modern hospital service." In the development of the index they omitted

TABLE VI

NUMBER OF HOSPITALS WITH CERTAIN FACILITIES AND TWO COMPLEXITY MEASURE WEIGHTING SCHEMES

Facility	(A) No. of Hospital Occurrences	(B) Percent of 457 Possible Occurrences	(C) Percent Not Having Facility	(D) $1-\frac{a_i}{3,239}$
Postoperative Recovery Room	316	69.1	30.9	.904
Physical Therapy Department	307	67.2	32.8	.906
Emergency Department	305	66.7	32.8	.907
Blood Bank	276	60.4	39.6	.916
Inhalation Therapy Department	223	48.8	51.2	.932
Intensive Cardiac Care Unit	211	46.2	53.8	.936
Intensive Care Unit	189	41.4	58.6	.942
Histopathology Laboratory	162	35.4	64.6	.951
Electroencepalography	149	32.6	67.4	.955
Premature Nursery	149	32.6	67.4	.955
X-Ray Therapy	136	29.8	70.2	.958
Diagnostic Radioisotope	135	29.5	70.5	.959
Occupational Therapy Department	117	25.6	74.4	.964
Organized Outpatient Department	109	23.9	76.1	.967
Radium Therapy	102	22.3	77.7	.968
Therapeutic Radioisotope	79	17.3	82.7	.976
Psychiatric Inpatient Unit	71	15.5	84.5	.978
Psychiatric Emergency Service	52	11.4	88.6	.984
Cobalt Therapy	44	9.6	90.4	.987
Inpatient Renal Dialysis	36	7.9	92.1	.989
Open Heart Surgery Facility	26	5.7	94.3	.993
Organ Bank	7	1.5	98.5	.998
Burn Care Unit	7	1.5	98.5	.998
Total Number of Facilities in 457 Wisconsin, Iowa, and Minnesota Hospitals	3,239			

certain commonplace facilities like diagnostic X-ray because these features "do little to differentiate one hospital from another." Also, since the authors assigned weights to each facility in accordance with their perception of the probable relative influence of the facility on patient outcome, some sophisticated facilities for diagnosis and therapy received relatively greater weighting.[26]

The Roemer, et al., index construction process points out that a facility complexity index can take on almost any direction as long as the ordinal positions of facilities are maintained; that is, that complex and costly facilities receive a consistently higher score than less complex facilities. Two different weighting schemes are used in this study. The first, shown in Column C of Table VI, simply assigns the proportion of hospitals <u>not</u> having the facility to each facility. Thus, for example, if a hospital added a relatively common postoperative recovery room to its existing facility structure, a value of 30.9 would be assigned to the "facilities added by expansion" variable which under this weighting scheme would be designated FACX1. The variable representing the existing facilities in a hospital is represented by FACS1 in this weighting scheme.

The second weighting scheme, shown in Column D of Table VI, weights each facility by its relative occurrence among all facilities (rather than hospitals) in these three states. That is, of the 3,239 facilities found in the short-term general hospitals of Wisconsin, Iowa, and Minnesota in 1971, 136 were X-ray therapy. Therefore a complexity, or more aptly scarcity, score of

$$1 - (136/3{,}239)$$

was assigned to X-ray therapy. A similar procedure was applied to the remaining facilities in Table VI by replacing 136 with the appropriate number of occurrences for each of the facilities. Under this approach, the "facilities added by expansion" variable is designated FACX2 and the "existing facilities" are represented by FACS2.

The two different weighting schemes are designed to test the sensitivity of the facility expansion variables upon hospital cost increases. The FACX1 measure has greater variability than the FACX2 measure and also places greater weight on the facilities which are less often found. There are no a priori reasons, however, to expect one measure to perform better than the other.

Both facility-complexity measures were applied to the existing and expanded facilities of the 68 Wisconsin, Iowa, and Minnesota hospitals which expanded facilities in 1971. Values for each of these variables (FACX1, FACX2, FACS1, and FACS2) for each hospital are contained in Table VIII in Chapter V. The noticeable characteristic about both of the complexity measures is the relationship between existing facilities and facilities added by expansion. FACX1 shows a positive relationship (0.23) with FACS1 (significant at the 0.06 level of confidence). This means that, under this measure of hospital facilities, complex hospitals in terms of existing facilities tend to add complex facilities. This is a sensible relationship since complex hospitals probably already have most simple facilities. The FACX2 measure shows no systematic statistical relationship to FACS2 ($r = 0.11$, $t = 0.90$). This relationship could mean that a good proportion of both simple and complex hospitals are adding a mixture of both simple and complex facilities.

On the basis of the arguments of Chapter II, it would be assumed that both measures of facilities added by expansion would have a positive effect upon costs over time. This in large part is due to the changing nature of the hospital's product as reflected by changes in long-run average cost conditions in the hospital.

As well, the greater the resource demands upon the hospital's structure, the greater the impact upon costs. Therefore, it would also be expected that, ceteris paribus, the higher the ratio of FACX to FACS, the greater the increase in average costs. These relationships are measured by RFACX1 and RFACX2, where RFACX1 = FACX1/FACS1 and RFACX2 = FACX2/FACS2.

The remaining variables identified as "determinants" of both supply and demand for hospital care shall receive less consideration than the previous two concepts. The hypothesized relationship between each variable and average cost over time has been discussed in Chapter III. In agreement with Feldstein's notion that precise definitions for variables included in any conceptual or empirical model should reflect (1) the level of aggregation, (2) the availability of data, and (3) the desirability of limiting the number of separate parameters, several variables in Chapter III have not been included.[27] In all cases, however, an attempt has been made to capture the essence of the argument presented in that chapter with an appropriate variable.

Labor

Costs could rise due to the labor component of hospital supply because of an increased usage of personnel per patient day of care or rising per unit labor costs. To capture these effects, three variables are measured. These include PADC, the personnel per patient (on average) used in the hospital; AVWAGE, the average annual payroll expense per full-time equivalent worker; and AWAGE, the average weekly earnings of all workers in the county in which the hospital is located. Ceteris paribus, each of these supply variables would be expected to exert a positive influence on average cost over time.

Non-labor Inputs

Non-labor inputs also contribute to cost increases by a higher application of these resources per unit of output or by increasing factor prices. Unfortunately, the only variable available to measure this, NPBED, which is the annual non-payroll expense per patient day, picks up both effects. This variable should also exert a positive influence on costs over time.

Institutional Determinants

One of the largest possible sources of cost change over time due to a feature intrinsic to the hospital itself is the level of efficiency or the productivity of the hospital's resources. A measure of factor productivity or hospital efficiency is, however, very difficult to develop.[28] One measure of at least the level of utilization in the hospital is the occupancy rate, OCC, which has already been discussed above in connection with an expansion in beds.

Determinants of the Demand for Hospital Care and Their Effect Upon Costs

One of the basic notions of the hospital cost inflation literature presented in Chapter III was that demand forces may be pulling average costs upward. This section identifies variables which capture these effects.

Patient Demand

High incomes appear to raise people's ability to purchase hospital care and to simultaneously increase the opportunity costs of not receiving medical treatment. Hospital insurance appears to lower the net price of hospital care to the patient-consumer and to increase the demand for hospital care. Data are not available for the insurance coverage of the three states included in this study. There is reason to believe, however, that the inability to measure variations in hospital insurance coverage is not overly critical. Somers has suggested that health insurance enrollments are highly correlated with income, education, and urbanization.[29] Thus, to the extent that Somers is correct, when one or more of these variables is included, the effects of insurance coverage upon hospital demand and cost are also included. Accordingly, INCOME, the per capita money income of each county with an expansion hospital, has been included. It is expected that high INCOME will exert a positive effect upon costs over time.

But should the unit of observation for this and other related variables be the county? What conditions exist when a hospital is located on a county border and its service area is composed of residents in several counties? While far from being a perfect unit of observation, the county has been shown to be an adequate measure of hospital service area.[30] Many variables such as income and demographic characteristics vary little between adjoining counties, although they may vary considerably over several parts of a state. Certainly, an improvement could be made in the measurement of variables such as INCOME for the hospitals located on the border of several counties by averaging the measurements for the associated counties. However, little change would occur in the measurements due to the relative homogeneity among adjoining counties.[31] Thus, to remain consistent, the unit of observation for INCOME and related demand variables is the county in which the hospital is located.

Physician Demand

Several variables could be used to reflect both the substitutionary effect of the physician as health resource and the demand-generating effect of the physician as consumer. GPBED, the number of general care physicians per short-term general bed in the county of the expansion hospital, is used to represent the substitutionary effect. To the extent that general practitioners perform most services in their office, high GPBED should be negatively associated with the average cost over time. SPBED, the number of specialists per short-term general bed in the county of the expansion hospital, is expected to exert a positive influence on costs.[32] As more specialists practice in an area, greater demands are placed on the hospital.

Market Characteristics

Several economic and demographic characteristics of a hospital service area affect costs. One factor is the relative number of people potentially needing a hospital bed. Ceteris paribus, the greater the number of people in a county per available bed, defined as PRESS, the greater the influence on cost increases. Salkever also used the average household size in each county as a proxy for the local demographic characteristics. A similar variable, HSIZE, is used in this study and is assumed to be negatively related to cost increases over time since a high average probably represents a prevalence of children--who typically are more healthy than other population groups. A variable, URBAN, which represents the percentage of a county's population living in communities of 2,500 people or more, can also be included. To the extent that the variable picks up the high cost of "life in the city," one can expect this variable to be positively related to cost changes over time. Average length of stay in the hospital, LOS, is also included to account for the type of illnesses represented by the users of the hospital. Generally, longer lengths of stay suggest more severe cases in short-term general hospitals and one would suspect more extensive and expensive treatment to be rendered.[33] Thus, LOS would be expected to exert a positive influence on hospital costs.

Summary

This chapter has attempted to develop a simple conceptual model which relates change in average cost over a period to equilibrium conditions at the end of the period and to average costs at the beginning of the period. Further effort was made to find variables which operationally define this conceptual model. The variables discussed, beginning with BEDX and concluding with URBAN, are merely elaborations upon the S_j and D_j (supply and demand parameters) contained in Equation (6). It was postulated that the level of each of these variables jointly determines the equilibrium level of average cost in a hospital each year. Thus, each supply and demand factor identified in this chapter had a an expected impact upon hospital average costs over time. The following chapter makes use of each of these variables in empirically testing for their combined effects upon costs over time.

FOOTNOTES

[1]See Martin Feldstein, "Hospital Cost Inflation," and Salkever.

[2]Martin Feldstein, "Hospital Cost Inflation," p. 854.

[3]Salkever, p. 1146.

[4]The concept of "output-determination function" and its relationship to the (hospital) cost function is clearly discussed in J. Johnston, _Statistical Cost Analysis_ (New York,, 1960), pp. 39-41.

[5]Ibid., p. 54.

[6]Martin Feldstein, "Hospital Cost Inflation," pp. 855-856.

[7]Paul Ginsburg, "Resource Allocation in the Hospital Industry: The Role of Capital Financing," _Social Security Bulletin_, XXXV (October 1972), p. 22.

[8]Paul Feldstein and J. Gorman, "Predicting Hospital Utilization: An Evaluation of Three Approaches," _Inquiry_, II (1965), pp. 13-36.

[9]Carr and Feldstein, p. 46.

[10]Conceptually, this discussion is very similar to the distinctions normally drawn between "changes in demand" and "changes in the quantity demanded."

[11]Ginsburg, p. 29.

[12]Carr and Feldstein, pp. 45-65.

[13]Berry, "Returns to Scale," pp. 123-139.

[14]Edgar Francisco, "Analysis of Cost Variations Among Short-Term General Hospitals," in Herbert Klarman (ed.), _Empirical Studies_, pp. 321-332.

[15]Berry, "Product Heterogeneity," pp. 67-75.

[16]Hales.

[17]Berry, "Product Heterogeneity," p. 71.

[18]Francisco, p. 328.

[19]Pettengill, p. 19.

[20]Berry, "Product Heterogeneity," pp. 74-75.

[21]Judith Lave and Lester Lave, "The Extent of Role Differentiation Among Hospitals," Health Services Research, VI (1971), p. 36.

[22]Brian Berry and William Garrison, "Recent Developments of Central-Place Theory," Papers and Proceedings of the Regional Science Association, IV (1958), pp. 107-120.

[23]Gunnar Olsson, "Central Place Systems, Spatial Interaction, and Stochastic Processes," in William Leahy, et al. (ed.), Urban Economics (New York, 1970), p. 178.

[24]Berry, "On Grouping Hospitals," pp. 5-12.

[25]Hospital facilities omitted include pharmacy, self-care and extended care units, psychiatric outpatient and emergency treatment, psychiatric foster and educational care, and all social work and family counseling type services.

[26]Milton Roemer, A. Taher Moustafa, and Carl Hopkins, "A Proposed Hospital Quality Index: Hospital Death Rates Adjusted for Case Severity," Health Services Research, III (1968), pp. 96-118.

[27]Martin Feldstein, "Hospital Cost Inflation," p. 859.

[28]Berry, "Product Heterogeneity," p. 70.

[29]Herman Somers and Anne Somers, Doctors, Patients, and Health Insurance (Washington, D.C., 1961), pp. 364-365.

[30]The most recent effort to establish health service areas using the county as the unit of observation is James Anderson, "Causal Model of a Health Services System," Health Services Research, VII (1972), pp. 23-42.

[31]Measurements for INCOME, PRESS, HSIZE, and URBAN for six hospitals located near county boundaries in Wisconsin were averaged using figures for the appropriate counties involved. Changes in the measurements among all of the variables were never greater than 0.4 percent.

[32]"Specialists" include all medical and surgical specialists other than general practice physicians.

[33]Judith Lave and Lester Lave, "Economic Analysis for Health Service Efficiency: A Review Article," Applied Economics, I (1970), p. 298.

CHAPTER V

STATISTICAL MODEL, DATA, AND EMPIRICAL RESULTS

Introduction

The present chapter defines the precise statistical model used in this study. This specification is based on the conceptual model and associated variables identified in Chapter IV. The hospitals included in the statistical analysis are identified and sources for the pertinent data are presented. The major emphasis of the chapter is in discussing the relative importance of each of the included variables in explaining cost inflation variations among hospitals which recently expanded. Special attention is given to the importance of expansion related variables in explaining hospital cost inflation.

Statistical Model and Test of Significance

The conceptual model of Chapter IV needs further elaboration or specification before it is useful for estimating the relative importance of each of the variables identified.

To begin, the model as presented in Equation (7) of Chapter IV can be specified in log form with the addition of the subscript i to reflect observations on the ith hospital and an error term, ε_t. This specification is shown in Equation (8), where all other symbols retain their previous meaning.

$$\ln AC_{it} - \ln AC_{it-1} = \lambda(\ln AC^*_{it} - \ln AC_{it-1}) + \varepsilon_t. \quad (8)$$

Subtracting $\ln AC_{it-1}$ from both sides of the equation and collecting terms yields

$$\ln AC_{it} = \lambda(\ln AC^*_{it}) + (1 - \lambda)(\ln AC_{it-1}) + \varepsilon_t. \quad (9)$$

As postulated in Equation (6), equilibrium average cost in the ith hospital is a function of the supply and demand determinants or variables identified in Chapter IV. This relationship can be specified in a multiplicative form such as

$$AC^*_{it} = A \cdot D^b_{it1} \quad D^c_{it2} \cdot \ldots D^n_{itm} \cdot S^o_{itn} \cdot S^p_{ito} \cdot \ldots S^s_{itr} \cdot Z_t. \quad (10)$$

Taking the log of Equation (10) and substituting into Equation (9), the model to be estimated is

$$\ln AC_{it} = \lambda a + \lambda b \ln D_{it1} + \lambda c \ln D_{it2} + \ldots \lambda s \ln S_{itr}$$
$$+ (1 - \lambda) \ln AC_{it-1} + \varepsilon'_t \quad (11)$$

where the total number of D_j and S_j variables equal r. It should be noted that certain S_j and D_j variables are entered into Equation (10) as e raised to the parameter (such as $e^{\alpha D_j}$ or $e^{\alpha S_j}$) in the cases where some observations on the variables are zero. This procedure is used to avoid the mathematical problems associated with taking the log of zero.[1]

An important characteristic of regression Equation (11) is that there are (r + 2) restricted coefficients since λ appears in every term.[2] The unrestricted counterpart to Equation (11) is

$$\ln AC_{it} = \beta_1 + \beta_2 \ln D_{it1} + \beta_3 \ln D_{it2} + \ldots \beta_s \ln S_{itr} + B_{s+1} \ln AC_{it-1} + \varepsilon'_t. \quad (12)$$

The coefficients of Equation (11) are related to the parameters of Equation (12) such that

$$\begin{aligned} \beta_1 &= \lambda a \\ \beta_2 &= \lambda b \\ &\vdots \\ \beta_s &= \lambda s \\ \beta_{s+1} &= (1 - \lambda). \end{aligned}$$

The regression model of Equation (11) has exact identification since there are (r + 2) restricted coefficients and (s + 1) equations. That is, a unique solution (separate from λ, the speed of adjustment) is possible for each of the restricted parameters included. By obtaining ordinary least square estimates of the unrestricted coefficients in Equation (12), the corresponding values in Equation (11) can be determined.[3]

The solution of each of the restricted coefficients in terms of the unrestricted coefficients is

$$\begin{aligned} a &= \frac{\beta_1}{1 - \beta_{s+1}} \\ b &= \frac{\beta_2}{1 - \beta_{s+1}} \\ &\vdots \\ s &= \frac{\beta_s}{1 - \beta_{s+1}} \\ \lambda &= 1 - \beta_{s+1} \end{aligned} \quad (13)$$

While the estimation of the regression equation presents no particular problems, the individual test for significance on each included variable is not quite as simple. The significance of AC_{t-1} in explaining the variation of AC_t can be determined by directly comparing its regression coefficient to its standard error using the information generated in obtaining the ordinary least squares estimate of Equation (12). This remains so because the $Var(\hat{\lambda})$ equals the $Var(\hat{\beta}_{s+1})$. The variances of the remaining restricted coefficients, however, are not equal to the variances of their unrestricted counterparts since the restricted estimators (a, b, c, ... s) are nonlinear functions of the unrestricted estimators. Thus, the tests of significance developed using the ordinary least squares information are not unbiased for each remaining variable in Equation (12)--asymptotic standard errors must be derived.[4]

To adjust for this nonlinear bias in the variance of the various estimators, a Taylor expansion is performed on each. The expansion (approximation) of each variance is

$$Var(\hat{\phi}) \approx \left[\frac{1}{1 - \hat{\beta}_{s+1}}\right]^2 Var(\beta_\phi) + \left[\frac{\hat{\beta}_\phi}{(1 - \hat{\beta}_{s+1})^2}\right]^2 Var(\hat{\beta}_{s+1})$$

$$+ 2\left[\frac{1}{1 - \hat{\beta}_{s+1}}\right]\left[\frac{\hat{\beta}_\phi}{(1 - \hat{\beta}_{s+1})^2}\right] Cov(\hat{\beta}_\phi, \hat{\beta}_{s+1}), \qquad (14)$$

where ϕ is the set of restricted estimators (i.e., ϕ = a,b,c,...s), $\hat{\beta}_\phi$ is the unrestricted estimator corresponding to each estimator in ϕ, and $\hat{\beta}_{s+1}$ is the ordinary least square estimator of ln AC_{t-1}.[5] These approximated variances can now be used in the usual tests of significance.

Hospital Selection and Data Sources

To test for the importance of expansions in explaining hospital cost inflation, all short-term general, non-teaching hospitals in Wisconsin, Iowa, and Minnesota were examined to ascertain whether or not they had expanded either beds or facilities during a recent time period. Because of reporting changes with respect to the facility structure of individual hospitals which occurred in available hospital information in 1970, the year 1971 was chosen as the base year of observation. Possible expansions were identified by comparing the characteristics of each hospital concerning the number of beds and types of facilities available in each hospital in the 1971 and 1972 American Hospital Association's Guide Issue Lists of Health Care Institutions.[6] Differences in these two characteristics in a particular hospital between the two years represented either an expansion in beds and/or facilities during the 1971 reporting year, or an error in reporting. With assistance of the American Hospital Association, reporting errors were eliminated and a final set of expansion hospitals established.

During the year 1971, 37 hospitals in the three states added additional beds and 68 hospitals added new facilities. The former group of hospitals is referred to throughout the remainder of this study as the "beds expansion" or BEDX hospitals and the latter group as the "facilities expansion" or FACX hospitals. Hospitals included in the BEDX group are shown in Table VII and the hospitals included in the FACX group are shown in Table VIII. As reflected by the last column in Table VII, some hospitals are included in both groups by virtue of their expanding both beds and facilities in 1971.

TABLE VII

SHORT-TERM GENERAL WISCONSIN, IOWA, AND
MINNESOTA HOSPITALS WHICH
ADDED BEDS IN 1971

Hospital	Existing Beds in 1971	Beds Added by Expansion	Percent New Beds of Existing Beds (RBEDX)	Expansion Also Including New Facilities
Wisconsin				
Appleton Memorial	242	26	10.7	
Baraboo St. Claire	102	3	2.9	
Beloit Memorial	228	62	27.2	
Burlington Memorial	123	29	23.6	
Green Bay Bellin	246	19	7.7	
Hayward Area	44	15	34.1	
Kaukauna Community	70	10	14.3	X
Kenosha St. Catherine	236	25	10.6	X
Madison General	512	39	7.6	X
Madison Methodist	280	26	9.3	
Madison St. Marys	360	28	7.8	
Manitowoc Holy Family	350	19	5.4	X
Marshfield St. Joe	422	9	2.1	X
Milwaukee Columbia	382	17	4.4	
Milwaukee Deaconess	290	34	11.7	
Milwaukee St. Joe	571	4	0.7	X
Monroe St. Claire	240	55	22.9	
New Berlin Memorial	116	5	4.3	

TABLE VII (Continued)

Hospital	Existing Beds in 1971	Beds Added by Expansion	Percent New Beds of Existing Beds (RBEDX)	Expansion Also Including New Facilities
Oconto Falls Community	98	52	53.1	
Rhinelander St. Marys	152	19	12.5	
Sheboygan Memorial	249	50	20.0	X
Viroqua Memorial	97	10	10.3	X
Waukesha Memorial	391	20	5.1	
Waupaca Riverside	77	9	11.7	
<u>Minnesota</u>				
Duluth Miller-Dwan	179	28	15.6	X
Milaca Area	45	14	31.1	X
Minneapolis Hennepin	405	12	3.0	
Minneapolis St. Marys	464	9	1.9	
Park Rapids	50	5	10.0	
Rochester Methodist	640	37	5.8	
St. Paul Mounds Park	216	42	19.4	
Trimont Community	24	5	20.8	
Worthington Regional	104	35	33.7	X
<u>Iowa</u>				
Carroll St. Anthony	128	18	14.1	X
Des Moines Mercy	366	5	1.4	
Sioux City St. Lukes	320	4	1.2	

TABLE VIII

SHORT-TERM GENERAL WISCONSIN, IOWA, AND MINNESOTA HOSPITALS WHICH ADDED FACILITIES IN 1971

Hospital	Code of Facilities Added*	Index of Existing Facilities FACS1	Index of Facilities Added FACX1	Index of Existing Facilities FACS2	Index of Facilities Added FACX2
Wisconsin					
Amery Apple	34	185.0	33.0	3.702	0.907
Baldwin Comm.	3,23	132.0	87.0	2.765	1.842
Berlin Mem'l.	3,12,34	255.0	152.0	4.565	2.794
Black River Falls	2	191.0	59.0	5.559	0.942
Chippewa Falls	10	610.0	70.0	10.317	0.959
Clintonville Comm.	2,12,14,34	215.0	197.0	4.604	3.716
Columbus Comm.	2	258.0	59.0	5.523	0.942
Cudahy Trinity	11	506.0	83.0	16.098	0.976
Eagle River Mem'l.	14,16	66.0	91.0	1.813	1.848
Eau Claire Luther	12,20	1,149.0	157.0	17.095	2.931
Fond du Lac St. Agnes	17	1,031.0	67.0	15.285	0.955
Fort Atkinson Mem'l.	3	274.0	54.0	5.547	0.936
Green Bay St. Mary	3,17	610.0	121.0	10.317	1.891
Green Bay St. Vincent	1,3,9, 14,30	938.0	292.0	14.350	4.709
Hazel Green	1	140.0	31.0	2.778	0.904
Kaukauna Comm.	12	326.0	65.0	6.478	0.951
Ladysmith St. Mary	2	173.0	59.0	3.684	0.942
Madison General	34	1,048.0	33.0	17.082	0.907

TABLE VIII (Continued)

Hospital	Code of Facil- ities Added*	Index of Existing Facil- ities FACS1	Index of Facil- ities Added FACX1	Index of Existing Facil- ities FACS2	Index of Facil- ities Added FACX2
Manitowoc Holy Family	3,16	1,055.0	105.0	16.103	1.868
Marshfield St. Joe	30	1,235.0	89.0	19.065	0.984
Menomonee Falls Comm.	17	463.0	67.0	8.391	0.955
Milwaukee St. Anthony	12	319.0	65.0	6.578	0.951
Milwaukee St. Joe	14,20	1,081.0	132.0	16.215	1.905
Neenah Theda	11	1,057.0	83.0	17.096	1.966
Oconomowoc	3,10	312.0	124.0	6.458	0.959
Prairie du Chien	3	188.0	54.0	4.565	0.936
Prairie du Sac	2,14	221.0	94.0	4.611	0.916
Racine St. Marys	24,34	589.0	107.0	10.287	1.871
Rhinelander St. Marys	3	571.0	54.0	9.402	0.936
Ripon Memorial	1	133.0	31.0	3.735	0.904
Sheboygan Mem'l.	17	898.0	67.0	14.161	0.955
Stevens Point St. Mikes	12	840.0	65.0	14.213	0.951
Viroqua	14	260.0	40.0	4.667	0.916
Waupun Memorial	2,7	425.0	129.0	8.469	1.900
Wautoma Memorial	14,23	182.0	73.0	3.698	1.822
Minnesota					
Albany Comm.	15,23	1.0	100.0	0.001	1.861
Albert Lea Naeve	2,9,17	539.0	204.0	9.381	1.924

TABLE VIII (Continued)

Hospital	Code of Facil- ities Added*	Index of Existing Facil- ities FACS1	Index of Facil- ities Added FACX1	Index of Existing Facil- ities FACS2	Index of Facil- ities Added FACX2
Baudette Trinity	3	73.0	54.0	1.823	0.936
Braham Comm.	14,16	109.0	91.0	1.874	1.848
Brainerd St. Joe	7,12,24	438.0	209.0	8.357	2.873
Duluth Miller-Dwan	3,23,24,27	590.0	245.0	10.551	3.784
Duluth St. Lukes	11	1,055.0	83.0	16.103	0.976
Fairmont Comm.	16	468.0	51.0	8.397	0.932
Milaca Area	1,3,15,23	200.0	185.0	3.722	3.701
Montevideo Chippewa	3	173.0	54.0	3.684	0.936
Waconia	2,10	292.0	129.0	5.573	0.959
Worthington	9,15,16	541.0	196.0	10.351	3.847
Iowa					
Burlington Mem'l.	15,16	797.0	138.0	12.299	1.887
Carroll St. Anthony	3,10,17	499.0	191.0	7.443	2.850
Cedar Falls Sartori	7	258.0	70.0	5.524	0.958
Centerville St. Joe	1	189.0	31.0	3.705	0.904
Clarion Comm.	23	73.0	33.0	1.823	0.906
Cresco St. Joe	2	33.0	59.0	0.907	0.942
Dubuque Finley	1,3,23	309.0	118.0	4.735	2.746
Harlan Shelby	10,14,16, 17	97.0	228.0	2.717	3.762
Iowa Falls	12	137.0	65.0	3.633	0.951

TABLE VIII (Continued)

Hospital	Code of Facil-ities Added*	Index of Existing Facil-ities FACS1	Index of Facil-ities Added FACX1	Index of Existing Facil-ities FACS2	Index of Facil-ities Added FACX2
Keokuk St. Joe	12,34	301.0	98.0	6.443	1.858
Marshalltown Area	1,3	702.0	85.0	11.349	0.904
Mason City	15	661.0	67.0	11.250	0.955
Missouri Valley Comm.	1	33.0	31.0	0.907	0.904
Oelwein Mercy	2	117.0	59.0	2.745	0.942
Onawa	2,23	212.0	92.0	3.739	0.906
Perry Dallas	1,3	33.0	85.0	0.907	1.840
Red Oak Murphy	23	33.0	33.0	4.616	0.906
Spencer Muni.	2	224.0	59.0	4.616	0.942
Storm Lake Buena	2,10,16	288.0	180.0	5.559	1.891
Waukon Veterans	2,10	256.0	129.0	5.520	0.959
Webster City Hamilton	16	191.0	51.0	4.569	0.932

*Facility codes correspond to facilities listed in Table XX of the Appendix.

The data sources used for the variables identified in Chapter IV and estimated in Equation (12) are shown in Table IX.

Empirical Results

Three sets of regressions are run on each group of hospitals. The first set examines the variation in cost increases among the hospitals over the one-year period following the expansion of beds or facilities. Thus, in this set of regressions, the dependent variable is the log of average cost in the hospital in 1972, and, correspondingly, data for the elements of AC_t^* (the D_js and S_js) are also for 1972 where possible. The lagged average cost variable is for 1971.

The second set of regressions, run again on both the group of hospitals that expanded beds and the group that expanded facilities, examines cost increase variations over the two-year period following expansion. Thus AC_t and AC_t^* variables refer to 1973 data where possible and AC_{t-1} is again average cost in the hospital in 1971, the year the hospital expanded.

A similar set of regressions can be run for the three-year period following expansion, with corresponding changes in the year of observation for the dependent and explanatory variables.[6]

In all sets of regressions, the dependent and lagged average cost variables are defined as the total annual expenses of the hospital divided by the total number of patient days of care provided in the hospital during the associated year of observation.

TABLE IX

DATA SOURCES FOR REGRESSION VARIABLES

Variable Name	Variable Description	Data Source	Years Available
AC_t, AC_{t-1}	Average cost in the present and base period, respectively. Defined as total expenses divided by total patient days for year of observation.	AHA Guide Issue	1971, 1972, 1973, 1974
BEDX	The number of beds added by expansion in 1971.	Derived from AHA Guide Issue	1971, 1972
OCC	Average annual occupancy rate.	AHA Guide Issue	1972, 1973, 1974
PATDAYS	Total patient days of care.	AHA Guide Issue	1972, 1973, 1974
PDSQ	Patient days squared.	AHA Guide Issue	1972, 1973, 1974
RBEDX	The relative number of beds added by expansion. Defined as BEDX divided by existing beds.	Derived from AHA Guide Issue	1971, 1972
FACX1	Index of facilities added by expansion in 1971 based upon relative occurrence of facilities in hospitals.	Derived from AHA Guide Issue	1971, 1972

TABLE IX (Continued)

Variable Name	Variable Description	Data Source	Years Available
RFACX1	The relative complexity of FACX1 compared to the existing facility structure in the hospital. Defined as FACX1 divided by the index of existing facilities.	Derived from AHA Guide Issue	1971, 1972
FACX2	Index of facilities added by expansion in 1971 based upon relative occurrence of facility among all facilities.	Derived from AHA Guide Issue	1971, 1972
RFACX2	The relative complexity of FACX2 compared to the existing facility structure in the hospital. Defined as FACX2 divided by the index of existing facilities.	Derived from AHA Guide Issue	1971, 1972
PADC	The number of personnel per average number of patients. Defined as the total number of personnel divided by the average daily census.	AHA Guide Issue	1972, 1973, 1974
AVWAGE	Average wage of all personnel in the hospital except physicians.	AHA Guide Issue	1972, 1973, 1974
AWAGE	Average wage of all workers in the county of an expansion hospital.	County Business Patterns, U.S. Bureau of the Census, CBP-72/73-17, 25, and 51	1972, 1973

TABLE IX (Continued)

Variable Name	Variable Description	Data Source	Years Available
INCOME	Per capita money income in the county of an expansion hospital.	Population Estimates and Projections, U.S. Bureau of the Census, P-25, Nos. 560, 568, and 594	1972
GPBED	Number of General Practitioners per general short-term hospital bed in the county of an expansion hospital.	Distribution of Physicians in the U.S., 1972/73, American Medical Association, 1973/1974	1972, 1973
		AHA Guide Issue	1972, 1973
SPBED	Number of Specialists per general short-term hospital bed in the county of an expansion hospital.	Distribution of Physicians	1972, 1973
PRESS	Population in the county of an expansion hospital per available short-term general beds in the county.	Population Estimates	1972, 1973
		AHA Guide Issue	1972, 1973
HSIZE	Average household size in the county of an expansion hospital.	General Population Characteristics, U.S. Bureau of the Census, PC(1)-B17/25/51, Table 16	1970
URBAN	Percentage of population in the county of an expansion hospital living in communities of 2,500 people or more.	Number of Inhabitants, U.S. Bureau of the Census, PC(1)-A17/25/51, Table 9.	1970
LOS	Average length of stay in the expansion hospital. Defined as PATDAYS divided by the number of admissions during the year.	AHA Guide Issue	1972, 1973, 1974

TABLE IX (Continued)

Variable Name	Variable Description	Data Source	Years Available
NPBED	Total nonpayroll expense in the hospital per bed.	AHA Guide Issue	1972, 1973, 1974.

Cost Variations Due to Beds Expansion

One-Year Period. The first step in examining the importance of "beds expansion" in explaining the one-year cost increases among the 37 hospitals which expanded beds is to examine the zero-order correlation coefficients of the explanatory variables suggested in Chapter IV. This examination is intended to detect signs of possible multicollinearity.

Multicollinearity in the data set has two major consequences for the problem at hand.[7] First, the relative importance of the various explanatory variables is difficult to uniquely ascertain when two or more variables move closely together. That is, an apparent relationship or lack of relationship between an explanatory variable and average cost over time may be due to the influence of another explanatory variable which moves concomitantly with the first variable. Secondly, estimates of regression coefficients become very sensitive to the particular data being used. Additional data may produce dramatic changes in the size and direction of estimated coefficients.

The correlation coefficients for the one-year, beds expansion data are presented in Table X. On the basis of the commonly accepted rule of thumb that zero-order correlation between two explanatory variables is less than 0.8 and watching that this correlation stays below the multiple correlation between the dependent and independent variables,[8] it appears that problems of multicollinearity will exist when either of the two facility structure measures FACX1 or FACX2 are used simultaneously with the relative facility expansion measures RFACS1 or RFACX2.

TABLE X

ZERO-ORDER CORRELATION COEFFICIENTS: BEDS EXPANSION/ONE-YEAR PERIOD

	BEDX	OCC	PAT-DAYS	PDSQ*	RBEDX	FACX1*	RFACX1*	FACX2*	RFACX2*	AV-WAGE	A-WAGE	NP-BED	PADC	IN-COME	GP-BED*	SP-BED*	PRESS	LOS	HSIZE	URBAN	AC71
BEDX	1.00	-.09	.16	-.04	.61	.08	.05	.11	.05	-.04	.14	-.23	.03	.17	-.22	.23	-.03	.11	.10	.05	.02
OCC		1.00	.34	.44	-.23	-.26	.00	-.25	-.11	.08	.08	.37	-.06	.14	-.02	.25	-.11	.13	-.38	-.13	.05
PATDAYS			1.00	.79	-.66	-.18	-.35	-.23	-.34	.50	.73	.46	.40	.49	-.35	.61	-.12	.34	-.06	.52	.53
PDSQ*				1.00	-.62	-.10	-.03	-.13	-.06	.40	.49	.36	.07	.36	-.28	.58	-.25	.31	-.18	.30	.30
RBEDX					1.00	.14	.29	.20	.28	-.44	-.49	-.51	-.34	-.27	.12	-.27	.01	-.20	.08	-.41	-.44
FACX1*						1.00	.82	NA	NA	-.03	-.23	-.32	-.13	-.26	-.18	-.20	-.22	.19	.02	-.02	-.12
RFACX1*							1.00	NA	NA	-.08	-.39	-.28	-.29	-.32	-.05	-.24	-.24	.04	.02	-.13	-.19
FACX2*								1.00	.92	-.05	-.28	-.36	-.15	-.26	-.16	-.20	-.20	.14	.01	-.04	-.12
RFACX2*									1.00	-.10	-.39	-.35	-.29	-.34	-.08	-.24	-.23	.04	.02	-.12	-.22
AVWAGE										1.00	.52	.62	.17	.35	-.23	.47	-.12	.39	.06	.55	.63
AWAGE											1.00	.40	.40	.63	-.28	.47	.04	.41	.19	.68	.61
NPBED												1.00	.49	.29	-.17	.26	.02	.11	-.12	.32	.81
PADC													1.00	.16	-.25	.21	.23	-.06	.03	.27	.74
INCOME														1.00	-.10	.41	-.04	.39	.03	.42	.36
GPBED*															1.00	.10	-.03	-.27	.10	-.18	.71
SPBED*																1.00	.48	.32	.37	.32	.41
PRESS																	1.00	-.22	.34	-.05	.17
LOS																		1.00	-.25	.23	.28
HSIZE																			1.00	.19	.03
URBAN																				1.00	.46

* Variables in non-log form.
NA Variables not used in same regression.
Number of observations: 37.

This is not especially critical in this set of hospitals since beds expansion is the expansion variable of most concern. Consequently, RFACX1 and RFACX2 are alternately dropped from the regression equation.

Similarly, it appears that NPBED, the amount of nonpayroll expense each hospital uses per bed, is highly correlated with the lagged average cost variable, AC71. Because of the importance of AC71 in the model and because of the repeated occurrence of high correlation between the two variables in all time periods and for both groups of hospitals, NPBED has been dropped from subsequent regression analyses.

A similar high correlation exists between the linear and quadratic forms of patient days, PATDAYS and PDSQ; however, both variables are retained since they are interpreted together.

Estimating Equation (12) with the full set of explanatory variables (other than those excluded above) produces Equation (15).

$$\begin{aligned} L\hat{A}C72 = & -2.166 + 0.293\ LBEDX - 0.342\ LRBEDX - 0.021\ FACX2 \\ & + 0.166\ LOCC - 0.355\ LPATDAYS + 0.000\ LPDSQ \\ & + 0.796\ LPADC + 0.774\ LAVWAGE - 0.087\ LAWAGE \\ & + 0.940\ GPBED + 0.201\ SPBED + 0.075\ LINCOME - 0.138\ LPRESS \\ & - 0.057\ LHSIZE - 0.085\ LLOS - 0.003\ LURBAN + \underset{(1.69)}{0.289}\ LAC71. \end{aligned} \tag{15}$$

$$F = 13.09 \qquad R^2 = .9252$$

Here, and in the following equations, L before a variable denotes a variable in natural log form.

The speed at which hospitals in this group converge toward equilibrium average cost in the one-year period following expansion is nearly three-fourths of the average cost gap. That is, 71.1 percent

(1 - .289) of the difference between the logarithms of AC_{it} and AC^*_{it} is closed within one year. In this model, the lagged average cost variable is significant at the .10 level.

Adjusting each regression coefficient for the implicit speed of adjustment (i.e., dividing each regression coefficient by 1 - .289) in accordance with Equation (13) produces what might be considered the "pure" effect of each variable upon average cost over time. The ratio of this estimate to its asymptotic standard error for each variable other than AC_{t-1} can be derived by employing Equation (14). The adjusted coefficients and their standard error ratios are shown in Equation (16), with the ratios shown in parentheses.

$$\begin{aligned} \hat{LAC72} = & \underset{(1.14)}{-3.046} + \underset{(1.62)}{0.412}\ LBEDX - \underset{(1.85)}{0.481}\ LRBEDX - \underset{(1.23)}{0.030}\ FACX2 \\ & + \underset{(0.89)}{-.233}\ LOCC - \underset{(1.13)}{0.499}\ LPATDAYS + \underset{(0.60)}{0.000}\ PDSQ + \underset{(3.40)}{1.118}\ LPADC \\ & + \underset{(3.62)}{1.087}\ LAVWAGE - \underset{(0.32)}{0.122}\ LAWAGE + \underset{(0.59)}{1.321}\ GPBED + \underset{(1.35)}{0.283}\ SPBED \\ & + \underset{(0.41)}{0.104}\ LINCOME - \underset{(1.04)}{0.194}\ LPRESS - \underset{(0.14)}{0.080}\ LHSIZE - \underset{(0.54)}{0.120}\ LLOS \\ & - \underset{(0.11)}{0.004}\ LURBAN + \underset{(1.69)}{0.711}\ LAC71. \end{aligned} \qquad (16)$$

The absolute beds expansion variable behaves as expansion regulation policy has assumed, although it is statistically insignificant at the 0.10 level.[10] The more beds added by a hospital in the present time period, the higher, ceteris paribus, average costs are likely to be one year hence.

For the range of expansions in this set of hospitals, it appears that the larger the expansion relative to initial size, the smaller the increase in costs--costs in fact decrease. This was typical of the range of expansions in Figure 6 of Chapter II which produced SAC_2, although contrary to earlier expectations that beds expansions can have "traumatic" effects upon costs when viewed relative to existing size.

But, most importantly, what is the composite effect of the two beds expansion variables on average cost over the one-year period? The typical effect can be shown by looking at an average expansion in the average hospital. By exponentiating Equation (16) and assuming that an expansion of 22.4 beds takes place in a hospital with 245 existing beds,[11] it appears that costs would rise by $3.60 or 4.5 percent per patient day due to the BEDX effect.[12] Concomitantly, costs would fall by $.32 or 0.4 percent per patient day due to the negative RBEDX effect. Thus, the effect of an average size expansion in an average size hospital would result in a net cost increase over the one-year period of 4.1 percent or $3.28 per patient day. It should be remembered, however, that these effects are somewhat dampened due to the fact that equilibrium average cost is not totally achieved within the one year following beds expansion.

Interestingly, the interaction between the absolute and relative beds expansion variables is such that the net effect on cost varies with size of hospital. Table XI shows the net effects of various size expansions which occur in a representative hospital with 245 existing beds and in a hospital with 100 existing beds. Two things are immediately observable. First, cost increases rise with the number of beds added to the existing beds in a hospital. For example, cost inflation due to beds expansion would be expected to be 2.2 percent over the one-year period if 5 beds are added to an existing 245 beds and to rise by 4.6

percent if 40 beds are added to the same hospital. Secondly, it is less inflationary to add a given number of beds to a smaller hospital than it is to add the same number of beds to a larger hospital. For example, 15 beds added to a 245-bed hospital would be expected to raise average costs by 3.5 percent, while the same 15 beds added to a 100-bed hospital would raise costs by 3.3 percent.

TABLE XI

EFFECTS OF BEDX AND RBEDX VARIABLES ON AVERAGE COST OVER ONE YEAR IN HOSPITALS OF 245 AND 100 EXISTING BEDS

	5 Beds		15 Beds		22.4 Beds		40 Beds	
	Absolute	Percent*	Absolute	Percent*	Absolute	Percent*	Absolute	Percent*
BEDS ADDED BY EXPANSION TO 245 EXISTING BEDS								
BEDX	$1.94	2.4	$3.05	3.8	$3.60	4.5	$4.57	5.8
RBEDX	- .15	-0.2	- .26	-0.3	- .32	-0.4	- .42	-0.5
Net	$1.79	2.2	$2.79	3.5	$3.28	4.1	$4.15	5.3
BEDS ADDED BY EXPANSION TO 100 EXISTING BEDS								
BEDX	$1.94	2.4	$3.05	3.8	$3.60	4.5	$4.57	5.8
RBEDX	- .24	0.3	- .40	-0.5	- .49	0.6	- .64	-0.8
Net	$1.70	2.1	$2.55	3.3	$3.11	3.9	$3.93	5.0

*Percentage change is based upon an average cost in 1971 of $79.31 which was typical for the hospitals in the BEDX group.

A certain amount of caution should be applied, however, in using the figures in Table XI since the BEDX variable was not quite statistically significant at the .10 level.

The other factors included in the full model which appear to have exerted the greatest influence on costs over the one-year period following beds expansions were the labor-related variables. The number of people a hospital uses per patient on an average day, PADC, and the average wage of hospital personnel, AVWAGE, were the only other variables which were statistically significant in explaining the variation in average costs over time. A one percent difference in the number of personnel per average daily census in one hospital over another meant approximately a 1.1 percent higher average cost in 1972. Similarly, a one percent higher average wage in one hospital over another meant approximately a 1.1 percent higher 1972 average cost. It should be remembered that both of these effects were softened to 0.80 and 0.77 percent annual increases, respectively, due to the slowness in the hospital system in moving to equilibrium average cost.

Although statistically insignificant, most of the remaining variables behaved as expected. Among the exceptions to this general rule was FACX2, which was the facility expansion variable included to adjust for those cases where both beds and facilities were added. The negative effect of new facilities on costs might suggest that in the few hospitals which added both beds and facilities, the facilities added complemented existing and new beds such that hospital efficiency increased.

Other counter-intuitive results include the negative effect of local wages, AWAGE, on costs, and the very small but negative effect of urbanization upon costs. The positive sign of GPBED in the "beds expansion" group of hospitals suggests that general practitioners are not acting as substitutes for general hospital services and that they are demanding hospital patient days as much as specialists.

One of the most surprising results of the one-year examination of cost changes for the BEDX hospitals is the negative sign on average length of stay, LOS. Others have also found this negative relationship, although its occurrence has not been theoretically explained.[12] To the extent that more expensive treatment is rendered in the early days of most hospital stays, one might expect average cost to be negatively related to average length of stay in the hospital.

In general, over the one-year period following the expansion of beds in a hospital, the labor-related variables appear to put a significant push upward against average cost in the hospital while the relative effect of new beds, working through the RBEDX variable, appears to be working slightly toward lower costs. The absolute number of beds added by expansion is a positive influence on costs over time and is very nearly significant at the 0.10 level.

A major question to be explored is the length of time these forces continue to exert their influence on costs. To address this question, the model is applied to the variation in cost increases over the two-year period following the beds expansion in 1971.

Two-Year Period. Again, the first step in this process is to examine the explanatory variables for possible signs of multicollinearity. Table XII contains the zero-order correlation coefficients for each of the variables used in this model for the 37 beds expansion hospitals. Once again, the absolute and relative facility expansion variables

TABLE XII

ZERO-ORDER CORRELATION COEFFICIENTS: BEDS EXPANSION/TWO-YEAR PERIOD

	BEDX	OCC	PAT-DAYS	PDSQ*	RBEDX	FACX1*	RFACX1*	FACX2*	RFACX2*	AV-WAGE	A-WAGE	NP-BED	PADC	IN-COME	GP-BED	SP-BED	PRESS	LOS	HSIZE	URBAN	AC71
BEDX	1.00	-.06	.20	-.01	.62	.05	.04	.07	.05	.13	.16	-.04	-.09	.14	-.21	.20	-.08	.16	.11	.06	.04
OCC		1.00	.63	.54	-.46	-.24	-.11	-.26	-.18	.38	.38	.49	.12	.28	-.09	.24	-.11	.16	-.22	.14	.24
PATDAYS			1.00	.95	-.62	-.13	-.30	-.18	-.29	.61	.70	.58	.38	.49	-.34	.53	-.13	.43	-.03	.52	.54
PDSQ*				1.00	-.01	-.09	-.03	-.13	-.06	.47	.47	.36	.15	.37	-.27	.43	-.29	.33	-.16	.30	.27
RBEDX					1.00	.11	.29	.18	.28	-.37	-.43	-.49	-.40	-.28	.11	-.27	.02	-.22	.09	-.39	-.41
FACX1*						1.00	.82	NA	NA	-.21	-.23	-.19	-.24	-.25	-.22	-.16	-.23	.26	.01	-.02	-.12
RFACX1*							1.00	NA	NA	-.13	-.36	-.18	-.39	-.32	.26	-.19	-.24	.06	.02	-.04	-.19
FACX2*								1.00	.92	-.20	-.27	-.21	-.27	-.25	-.20	-.17	-.21	.22	.00	-.05	-.12
RFACX2*									1.00	-.10	-.37	-.25	-.39	-.34	.20	-.19	-.23	.08	.02	-.04	-.22
AVWAGE										1.00	.63	.59	.34	.39	-.23	.40	-.03	.20	.10	.55	.71
AWAGE											1.00	.43	.45	.61	-.25	.47	.06	.38	.22	.68	.59
NPBED												1.00	.68	.29	-.41	.22	.01	.18	-.12	-.21	.80
PADC													1.00	.29	-.19	.28	.18	.02	-.10	.27	.70
INCOME														1.00	-.10	.41	-.04	.40	.02	.42	.36
GPBED*															1.00	.31	.74	-.22	.16	-.34	-.22
SPBED*																1.00	.48	.23	.37	.35	.41
PRESS																	1.00	-.20	.35	-.04	.18
LOS																		1.00	-.17	.26	.33
HSIZE																			1.00	.19	.03
URBAN																				1.00	.46

* Variables in non-log form.
NA Variables not used in same regression.
Number of observations: 37.

cannot be used together, and the nonpayroll expense per bed variable, NPBED, will not be used because of its high correlation with the lagged average cost variable, AC71.

Equation (12), estimated for the two-year period following the 1971 beds expansion in the 37 hospitals, produces Equation (17).

$$\begin{aligned} \widehat{LAC73} = &-0.868 + 0.167\ LBEDX - 0.186\ LRBEDX + 0.000\ FACX1 + 0.067\ LOCC \\ &- 0.162\ LPATDAYS + 0.000\ PDSQ + 0.732\ LPADC + 0.564\ LAVWAGE \\ &- 0.156\ LAWAGE - 0.174\ GPBED + 0.357\ SPBED - 0.012\ LINCOME \\ &- 0.094\ LPRESS - 0.104\ LHSIZE - 0.057\ LLOS \\ &+ 0.002\ LURBAN + \underset{(3.35)}{0.316}\ LAC71. \end{aligned} \tag{17}$$

$$F = 19.96 \qquad R^2 = .9496$$

Average cost over the two-year period converges toward the 1973 equilibrium at the rate of 68.4 percent of the gap between the logarithms of AC^*_{i73} and AC_{i71}. Adjusting each of the regression coefficients in Equation (17) by the speed of adjustment and calculating adjusted variances for each coefficient produces Equation (18).

$$\begin{aligned} \widehat{LAC73} = &\underset{(0.47)}{-1.268} + \underset{(0.37)}{0.244}\ LBEDX - \underset{(0.41)}{0.270}\ LRBEDX + \underset{(0.12)}{0.000}\ FACX1 + \underset{(0.26)}{0.098}\ LOCC \\ &- \underset{(0.32)}{0.237}\ LPATDAYS + \underset{(1.57)}{0.000}\ PDSQ + \underset{(4.26)}{1.069}\ LPADC + \underset{(3.81)}{0.823}\ LAVWAGE \\ &- \underset{(0.77)}{0.228}\ LAWAGE - \underset{(0.17)}{0.254}\ GPBED + \underset{(1.70)}{0.522}\ SPBED \\ &- \underset{(0.07)}{0.018}\ LINCOME - \underset{(0.95)}{0.137}\ LPRESS - \underset{(0.26)}{0.152}\ LHSIZE \\ &- \underset{(0.43)}{0.083}\ LLOS + \underset{(0.11)}{0.003}\ LURBAN + \underset{(3.35)}{0.684}\ LAC71. \end{aligned} \tag{18}$$

Ratios of asymptotic standard errors to the adjusted coefficients are again shown in parentheses.

Over this longer period, labor-related variables continue to play a major role in rising hospital average costs. A one percent higher ratio of personnel to the average number of patients treated each day raised costs in 1973 by 1.1 percent. A similar one percent higher average wage for hospital personnel raised costs by .82 percent.

The beds expansion variables clearly lose their importance in systematically explaining the variation in cost increases over the two-year period. The previously significant RBEDX variable remained negative but its level of statistical significance fell more than half to 0.41. Similarly, BEDX remained positive and its level of statistical significance fell dramatically. The ratios of standard error to estimator, or "standard error ratios," for OCC and PATDAYS fell dramatically also.

The forces other than labor and beds expansions which were at work in the hospital to raise costs appear to have been exerting only slight and nonsystematic influences on costs over the two-year period. Other wage levels in the area, income levels, the number of people per bed in the county, the relative number of general practitioners, bigger families, and lengths of hospital stay appear to have been exerting negative influences on hospital costs in the 37 beds expansion hospitals. The relative number of specialists and urbanization pressures appear to have been exerting positive influences on costs over the two-year period, but here again none of the variables were close to being statistically significant at the 0.05 or 0.10 level.

What is the general picture concerning the effects of beds expansions upon costs over time?

It appears that the absolute number of beds added by expansion does positively affect costs in the first year following expansion, although a higher level of statistical significance could be hoped for in this variable. Given the size of the average expansion which occurred in Wisconsin, Iowa, and Minnesota short-term general hospitals during 1971, the direct effect of new beds in an average hospital may result in cost increases of approximately 4.5 percent during the first year following beds expansion.

The beds expansion effect upon cost appears to be ubiquitous with regard to specific characteristics within the hospitals. That is, the level of occupancy or the level of output, as measured by patient days of care delivered, appear to exert very little systematic influence upon costs over time. The RBEDX variable is an exception to this rule in that it is negative and statistically significant at the .10 level. Unfortunately, the negative influence of RBEDX is very slight--causing average costs to lower by only 0.4 percent in the one-year period following the typical 1971 beds expansion.

Most importantly, perhaps, it appears that, when viewed over the two-year period following beds expansion, none of the individual and related expansion effects--including the relative number of beds added by expansion--exert any systematic effects on average hospital costs. The forces which bed expansions exert upon costs appear to get lost very quickly in a system of constantly increasing alternative cost dynamics. This remained true in an examination of the three-year cost increases among the BEDX hospitals which is not reported here.

The following section examines cost increase variations for the hospitals which expanded facilities in 1971.

Cost Variations Due to Facilities Expansion

One-Year Period. A similar process is followed in examining the importance of "facilities expansions" in explaining the variation in the one-year cost increases among the 68 hospitals which expanded facilities in 1971. Table XIII shows that multicollinearity problems should be minimal for most of the variables in this model.

In the remaining analysis of this study, only the equation showing adjusted regression coefficients and asymptotic standard error ratios (such as Equations (16) and (17)) will be shown. In each case, however, the original ordinary least square estimates for the unrestricted regression equation can be determined by multiplying the reported coefficient for each variable by the reported coefficient of the lagged average cost variable and by replacing the reported lagged average cost variable by one minus itself.

Two equations are estimated for the one-year period following facilities expansion in the 68 FACX hospitals and are shown in Table XIV. The first, Equation (19), uses the "relative hospital occurrence" or FACX1 measure of facilities expansion. The second, Equation (20), uses the "relative facility occurrence" or FACX2 measure.

The most important finding contained in the equations of Table XIV is that facility expansions in 1971 appear to have little systematic effect upon cost increases over the one-year period following expansion. The coefficients for both the absolute measures of facilities expansions

TABLE XIII

ZERO-ORDER CORRELATION COEFFICIENTS: FACILITIES EXPANSION/ONE-YEAR PERIOD

	FACX1	RFACX1	FACX2	RFACX2	BEDX*	OCC	PAT-DAYS	PDSQ*	AV-WAGE	A-WAGE	NP-BED	PADC	IN-COME	GP-BED*	SP-BED*	PRESS	LOS	HSIZE	URBAN	AC71
FACX1	1.00	.21	NA	NA	.09	.08	.23	.13	.29	.19	.20	.05	.10	-.21	.00	-.18	.31	.24	.17	.22
RFACX1		1.00	NA	NA	-.28	-.10	-.64	-.43	-.25	-.45	-.07	-.45	-.39	.29	-.39	-.04	-.05	.04	-.23	-.32
FACX2			1.00	.45	.14	.04	.14	.10	.10	.08	.15	.04	-.11	-.19	-.06	-.24	.34	.11	.03	.12
RFACX2				1.00	-.25	-.25	-.70	-.47	-.32	-.55	-.15	-.40	-.47	.38	-.47	.04	-.13	-.05	-.35	-.38
BEDX*					1.00	.05	.30	.26	-.04	.13	-.10	.15	.14	-.32	.23	-.23	.35	.02	.13	.11
OCC						1.00	.42	.31	.13	.19	.33	-.10	.10	-.16	.20	-.06	.14	.09	.27	.06
PATDAYS							1.00	.78	.51	.70	.40	.35	.45	-.54	.53	-.16	.43	.12	.46	.52
PDSQ*								1.00	.42	.47	.34	.18	.33	-.39	.45	-.15	.34	.03	.25	.37
AVWAGE									1.00	.47	.39	.13	.38	-.21	.40	.13	.33	.27	.36	.59
AWAGE										1.00	.41	.44	.43	-.58	.57	-.09	.37	.35	.45	.56
NPBED											1.00	.33	.34	-.40	.48	.14	.20	.20	.35	.80
PADC												1.00	.33	-.28	.45	.03	.10	.12	.42	.70
INCOME													1.00	-.15	.46	.15	.20	.09	.38	.46
GPBED*														1.00	-.14	.71	-.33	-.19	-.22	-.32
SPBED*															1.00	.36	.25	.27	.32	.64
PRESS																1.00	-.21	.06	.05	.11
LOS																	1.00	-.08	.13	.31
HSIZE																		1.00	.18	.29
URBAN																			1.00	.45

* Variables in non-log form.
NA Variables not used in same regression.
Number of observations: 68.

TABLE XIV

REGRESSION MODELS WITH FACX1 AND FACX2 FACILITY EXPANSION VARIABLES - ADJUSTED FOR SPEED OF ADJUSTMENT (RATIO OF ESTIMATOR TO ASYMPTOTIC STANDARD ERROR): ONE-YEAR PERIOD

$$
\begin{aligned}
LA\hat{C}72 = {} & \underset{(2.75)}{-5.954} + \underset{(0.63)}{0.026}\ LFACX1 + \underset{(0.29)}{0.010}\ LRFACX1 - \underset{(1.49)}{0.003}\ BEDX - \underset{(0.39)}{0.060}\ LOCC - \underset{(0.25)}{0.018}\ LPATDAYS \\
& + \underset{(0.40)}{0.000}\ PDSQ + \underset{(3.76)}{0.924}\ LPADC + \underset{(3.45)}{0.841}\ LAVWAGE + \underset{(0.08)}{0.016}\ LAWAGE + \underset{(1.12)}{1.564}\ GPBED \\
& + \underset{(0.94)}{0.233}\ SPBED + \underset{(1.15)}{0.245}\ LINCOME - \underset{(1.27)}{0.187}\ LPRESS + \underset{(0.13)}{0.044}\ LHSIZE + \underset{(0.57)}{0.090}\ LLOS \\
& + \underset{(1.00)}{0.018}\ LURBAN + \underset{(4.69)}{0.502}\ LAC71.
\end{aligned}
\qquad (19)
$$

$F = 26.89 \qquad R^2 = .9050$

$$
\begin{aligned}
LA\hat{C}72 = {} & \underset{(3.27)}{-7.171} + \underset{(0.14)}{0.010}\ LFACX2 + \underset{(0.51)}{0.045}\ LRFACX2 - \underset{(1.00)}{0.002}\ BEDX - \underset{(0.33)}{0.049}\ LOCC - \underset{(0.05)}{0.004}\ LPATDAYS + \underset{(0.50)}{0.000}\ PDSQ \\
& + \underset{(3.67)}{0.921}\ LPADC + \underset{(3.50)}{0.855}\ LAVWAGE + \underset{(0.11)}{0.022}\ LAWAGE + \underset{(1.07)}{1.487}\ GPBED + \underset{(0.97)}{0.234}\ SPBED + \underset{(1.47)}{0.295}\ LINCOME \\
& - \underset{(1.27)}{0.185}\ LPRESS + \underset{(0.21)}{0.067}\ LHSIZE + \underset{(0.54)}{0.081}\ LLOS + \underset{(1.61)}{0.018}\ LURBAN + \underset{(4.69)}{0.509}\ LAC71.
\end{aligned}
\qquad (20)
$$

$F = 27.25 \qquad R^2 = .9061$

(FACX1 and FACX2) and the relative measures of facilities expansions (RFACX1 and RFACX2) are positive as expected, although the adjusted standard errors always exceed the regression coefficients. On the basis of the percentage of the variation in 1972 average cost explained by both equations(i.e., R^2), it appears that the relative facility occurrence or FACX2 measure of facilities expansion performs better than the FACX1 measures.

The forces which appear to be most at work to raise costs in the hospitals which expanded facilities were again labor related. A one percent rise in the number of personnel per average number of patients gave rise to approximately a 0.92 percent average increase in average cost over the one-year period. A one percent rise in the average wage of hospital personnel gave rise to approximately a 0.85 percent average rise in average cost over the same period. These average coefficients (for the two equations in Table XIV) reflect considerably less influence than the same variables in the beds expansion hospitals.

Some of the remaining variables in the model continue to display relationships to average cost which are counter-intuitive, although these variables also continue to be generally statistically insignificant. A greater number of general practitioners per available bed in the county continued to suggest a positive influence on average costs. Thus, it would appear prima facie that general practitioners serving in expansion hospital counties are acting as hospital resource consumers rather than substitutes. A similar situation exists with PRESS, the population-to-beds ratio in the county. A relative scarcity of beds vis-a-vis population appears to be driving hospital costs down.

Several variables in the one-year facilities expansion model become consistent with theoretical expectations as opposed to their relationship to cost in the beds expansion hospitals, and one variable falls from its theoretical grace. Most noticeably, length of stay is positively related to average cost in this group of hospitals, suggesting that more complicated cases do require more costly treatment. Average wage of all workers in the county is also positively related to hospital costs over time as expected--although both variables remain statistically insignificant. The level of occupancy in the hospitals changes from its expected positive relationship to costs to an insignificant, slightly negative relationship.

The lagged average cost variable in both of the models of Table XIV remains strongly significant.

In general, over the one-year period following the expansion of facilities in a hospital, the labor-related variables continue to exert a strong positive influence on costs, much as in the beds expansion hospitals. New facilities appear to have little systematic impact upon costs during the first year. The following section examines this relationship for the FACX hospitals over the two-year period following expansion. There, it will be determined whether or not the facilities expansion relationship to costs deteriorates between the first and second years following expansion, as did the beds expansion relationship.

Two-Year Period. To examine the variation in cost increases over the two-year period following facilities expansion, the zero-order correlation coefficients for this group of hospitals are once again examined. This information, contained in Table XV, reflects that multicollinearity conditions remain unchanged.

Two equations are again estimated for the two-year period, using in each case a different pair of facility expansion variables. These equations are shown in Table XVI. Equation (21) incorporates the FACX1 facility expansion variable and Equation (22) the FACX2 variable.

The results shown in Table XVI suggest that new facilities as measured by the absolute FACX1 measure have a much more positive, systematic effect upon costs over the two-year period, although the variable remains statistically insignificant at the .10 level. The other facility expansion variables in Equations (21) and (22) remain positive but insignificant. The FACX1 variables appear to perform better over the two-year period than do the FACX2 variables on the basis of the percent of variation explained overall.

The beds simultaneously added by expansion reflect a significant positive effect upon costs over the two-year period, although this effect is very small.

All other variables remain as previously mentioned, although average length of stay, LOS, has reverted to a significant, negative relationship with cost. The beds-per-population ratio continued as a negative influence on costs, although this variable remained insignificant at the .10 level. Labor variables remained the strongest positive influence on costs over time.

In general, it appears that facilities added by expansion continue to play an insignificant statistical role in explaining the variation in

TABLE XV

ZERO-ORDER CORRELATION COEFFICIENTS: FACILITIES EXPANSION/TWO-YEAR PERIOD

	FACX1	RFACX1	FACX2	RFACX2	BEDX*	OCC	PAT-DAYS	PDSQ*	AV-WAGE	A-WAGE	NP-BED	PADC	IN-COME	GP-BED*	SP-BED*	PRESS	LOS	HSIZE	URBAN	AC71
FACX1	1.00	.21	NA	NA	.09	.10	.25	.14	.14	.17	.26	.03	.10	-.20	.06	-.18	.25	.24	.17	.22
RFACX1		1.00	NA	NA	-.28	-.15	-.64	-.45	-.26	-.45	-.18	-.38	-.39	.31	-.35	.03	-.19	.04	-.23	-.32
FACX2			1.00	.45	.14	.11	.16	.10	.02	.07	.19	-.03	-.11	-.17	-.03	-.24	.31	.11	.03	.12
RFACX2				1.00	-.25	-.28	-.69	-.50	-.37	-.53	-.26	-.31	-.47	.38	-.45	.04	-.23	-.05	-.35	-.38
BEDX*					1.00	.08	.33	.29	.05	.12	.12	-.06	.14	-.31	.16	-.23	.45	.02	.13	.11
OCC						1.00	.57	.34	.26	.31	.63	-.22	.22	-.19	.32	-.02	.29	.05	.26	.16
PATDAYS							1.00	.78	.50	.68	.51	.20	.47	-.54	.50	-.18	.51	.13	.45	.52
PDSQ*								1.00	.43	.48	.46	.16	.35	-.40	.36	-.17	.40	.05	.26	.37
AVWAGE									1.00	.59	.41	.06	.36	-.30	.46	.03	.22	.28	.23	.59
AWAGE										1.00	.45	.29	.44	-.49	.58	-.08	.37	.34	.45	.57
NPBED											1.00	.27	.42	-.45	.60	.07	.16	.28	.29	.78
PADC												1.00	.18	-.11	.31	.16	-.11	.12	.36	.56
INCOME													1.00	-.10	.43	.15	.27	.09	.38	.46
GPBED*														1.00	-.04	.72	-.37	-.20	-.23	-.34
SPBED*															1.00	.39	.23	.37	.31	.60
PRESS																1.00	-.21	.06	.05	.11
LOS																	1.00	-.03	.14	.33
HSIZE																		1.00	.18	.29
URBAN																			1.00	.45

* Variables in non-log form.
NA Variables not used in same regression.
Number of observations: 68.

TABLE XVI

REGRESSION MODELS WITH FACX1 AND FACX2 FACILITY EXPANSION VARIABLES - ADJUSTED FOR SPEED OF ADJUSTMENT (RATIO OF ESTIMATOR TO ASYMPTOTIC STANDARD ERROR): TWO-YEAR PERIOD

$$\begin{aligned}
\widehat{LAC73} = {} & \underset{(3.20)}{-5.388} + \underset{(1.15)}{0.034}\ LFACX1 + \underset{(0.14)}{0.003}\ LRFACX1 + \underset{(1.72)}{0.003}\ BEDX + \underset{(1.32)}{0.144}\ LOCC - \underset{(0.80)}{0.050}\ LPATDAYS + \underset{(0.28)}{0.000}\ PDSQ \\
& + \underset{(4.58)}{1.34}\ LPADC + \underset{(4.38)}{0.758}\ LAVWAGE + \underset{(0.09)}{0.012}\ LAWAGE + \underset{(1.12)}{0.964}\ GPBED + \underset{(1.20)}{0.259}\ SPBED + \underset{(1.03)}{0.170}\ LINCOME \\
& - \underset{(1.59)}{0.151}\ LPRESS + \underset{(0.53)}{0.125}\ LHSIZE - \underset{(1.88)}{0.287}\ LLOS + \underset{(0.72)}{0.009}\ LURBAN + \underset{(5.08)}{0.582}\ LAC71. \qquad (21)
\end{aligned}$$

$F = 32.72 \qquad R^2 = .9206$

$$\begin{aligned}
\widehat{LAC73} = {} & \underset{(3.31)}{-5.595} + \underset{(0.35)}{0.019}\ LFACX2 + \underset{(0.33)}{0.020}\ LRFACX2 + \underset{(1.70)}{0.003}\ BEDX + \underset{(1.16)}{0.127}\ LOCC - \underset{(0.59)}{0.036}\ LPATDAYS + \underset{(0.14)}{0.000}\ PDSQ \\
& + \underset{(5.25)}{1.029}\ LPADC + \underset{(4.43)}{0.766}\ LAVWAGE - \underset{(0.01)}{0.002}\ LAWAGE + \underset{(1.08)}{0.924}\ GPBED + \underset{(1.20)}{0.261}\ SPBED + \underset{(1.28)}{0.212}\ LINCOME \\
& - \underset{(1.61)}{0.151}\ LPRESS + \underset{(0.75)}{0.169}\ LHSIZE - \underset{(1.89)}{0.283}\ LLOS + \underset{(0.71)}{0.008}\ LURBAN + \underset{(4.92)}{0.590}\ LAC71. \qquad (22)
\end{aligned}$$

$F = 32.44 \qquad R^2 = .9199$

average cost over time as described by either of the facility expansion variables. However, it does appear, at least for the FACX1 measure, that this role is increasing over time. That is, the FACX1 variable is becoming more significant over longer periods of time--which is in contrast to the BEDX variables whose statistical significance deteriorated over time. This relationship might suggest that facility expansions have a long-term effect which takes several periods to become expressed. The examination of cost increases over the three-year period following facility expansion which is contained in the following section addresses this question.

Three-Year Period. The zero-order correlation coefficients for the variables included in the model for the three-year period following facility expansion are shown in Table XVII. Two hospitals are dropped from the FACX group for this period due to lack of information. Potential for multicollinearity problems continues to appear minimal, with the exceptions of PATDAYS and PDSQ, and NPBED. These variables continue to be treated as before, with NPBED dropped from the model and PATDAYS and PDSQ interpreted jointly.

As reported in Table XVIII, the relationship previously discussed concerning an improved statistical significance of the FACX1 variable over longer periods of time following expansion did not hold up. The ratio of the estimator to adjusted standard error for the FACX1 variable fell from 1.15 to 0.39 between the two- and three-year periods following expansion. The coefficient also turned to an unexpected negative sign in the three-year period.

TABLE XVII

ZERO-ORDER CORRELATION COEFFICIENTS: FACILITIES EXPANSION/THREE-YEAR PERIOD

	FACX1	RFACX1	FACX2	RFACX2	BEDX*	OCC	PAT-DAYS	PDSQ*	AV-WAGE	A-WAGE	NP-BED	PADC	IN-COME	GP-BED	SP-BED	PRESS	LOS	HSIZE	URBAN	AC71
FACX1	1.00	.21	NA	NA	.09	.18	.26	.15	.27	.17	.21	.03	.10	-.20	.06	-.18	.25	.24	.17	.22
RFACX1		1.00	NA	NA	-.28	-.21	-.64	-.44	-.26	-.45	-.06	-.39	-.39	.31	-.35	.03	-.20	.04	-.23	-.32
FACX2			1.00	.45	.14	.15	.17	.12	.15	.07	.16	-.13	-.11	-.17	-.03	-.24	.29	.11	.03	.12
RFACX2				1.00	-.25	-.31	-.69	-.48	-.36	-.53	-.15	-.34	-.47	.38	-.45	.04	-.26	-.05	-.35	-.38
BEDX*					1.00	.14	.34	.27	.04	.12	-.11	-.03	.14	-.31	.16	-.23	.42	.02	.13	.11
OCC						1.00	.63	.41	.42	.35	.30	-.14	.29	-.19	.41	.01	.34	.16	.28	.26
PATDAYS							1.00	.77	.58	.67	.40	.19	.48	-.53	.51	-.18	.54	.14	.46	.53
PDSQ*								1.00	.41	.48	.31	.15	.35	-.39	.36	-.15	.44	.07	.26	.38
AVWAGE									1.00	.57	.38	.03	.41	-.35	.41	-.03	.32	.33	.22	.60
AWAGE										1.00	.43	.30	.44	-.49	.58	-.08	.40	.34	.45	.57
NPBED											1.00	.30	.34	-.40	.45	.15	.20	.21	.35	.79
PADC												1.00	.16	-.10	.35	.14	-.15	.04	.25	.49
INCOME													1.00	-.10	.43	.15	.30	.09	.38	.46
GPBED*														1.00	-.04	.72	-.36	-.20	-.23	-.34
SPBED*															1.00	.39	.25	.37	.31	.60
PRESS																1.00	-.18	.06	.05	.11
LOS																	1.00	.01	.21	.35
HSIZE																		1.00	.18	.29
URBAN																			1.00	.45

* Variables in non-log form.
NA Variables not used in same regression.
Number of observations: 66.

TABLE XVIII

REGRESSION MODELS WITH FACX1 AND FACX2 FACILITY EXPANSION VARIABLES - ADJUSTED FOR SPEED OF ADJUSTMENT (RATIO OF ESTIMATOR TO ASYMPTOTIC STANDARD ERROR): THREE-YEAR PERIOD

LAC74 = -7.361 - 0.013 LFACX1 + 0.025 LRFACX1 + 0.001 BEDX + 0.238 LOCC - 0.007 LPATDAYS + 0.000 PDSQ
(4.368) (0.39) (1.00) (1.00) (2.40) (0.13) (0.94)

+ 1.138 LPADC + 0.860 LAVWAGE + 0.031 LAWAGE + 1.331 GPBED - 0.014 SPBED + 0.256 LINCOME
(7.59) (4.62) (0.24) (1.52) (0.06) (1.66)

- 0.185 LPRESS + 0.303 LHSIZE - 0.152 LLOS - 0.006 LURBAN + 0.715 LAC71. (23)
(1.88) (1.37) (1.16) (0.47) (3.12)

F = 21.22 R^2 = .8826

LAC74 = -7.438 - 0.049 LFACX2 + 0.081 LRFACX2 + 0.001 BEDX + 0.231 LOCC + 0.011 LPATDAYS + 0.000 PDSQ
(0.85) (1.21) (1.00) (2.46) (0.20) (1.06)

+ 1.125 LPADC + 0.865 LAVWAGE + 0.025 LAWAGE + 1.185 GPBED + 0.037 SPBED + 0.257 LINCOME
(10.03) (4.78) (0.20) (1.40) (0.16) (1.68)

- 0.184 LPRESS + 0.308 LHSIZE - 0.130 LLOS - 0.003 LURBAN + 0.728 LAC71. (24)
(1.92) (1.45) (1.03) (0.25) (2.97)

F = 21.67 R^2 = .8847

Other facility expansion variables did improve, however, in the examination of three-year cost increases. The RFACX1, FACX2, and RFACX2 variables all increased their estimator-to-standard error ratios from roughly 0.2 to approximately 1.0. While quite an improvement between the two periods, all facility expansion variables remain statistically insignificant at the .10 level.

With the improvement in the statistical significance of several of the facility expansion variables over longer periods of time, it would be interesting to examine cost increases over the four-year period following expansion. Unfortunately, this information is not currently available and thus this task remains for future analysis.

Over the three-year period following facilities expansion in the 66 hospitals remaining in this group, labor-related variables continued to exert the strongest positive influence on costs. One percent increases in either the number of personnel per average number of patients treated or the average wage of hospital personnel led to approximately a 0.8 to 1.1 percent rise in hospital average costs.

The level of occupancy and area incomes also appeared to play a positive and significant role in rising hospital costs. If true to theory, the rising costs associated with higher occupancy rates reflect short-run scale economies being exhausted while the positive relationship with income reflects rising demand pressures.

The persistent negative and statistically significant relationship between average length of stay and hospital cost is both perplexing and deserving of future study. It would appear, on the basis of information presented here, that longer stays are, on average, less expensive than shorter stays.

The general finding concerning facilities expansion after an examination of the one-, two-, and three-year cost increases is that there appears to be no systematic relationship between facilities expansion and hospital cost increases over time. Because of the implications of this finding for attempts to slow hospital cost inflation through expansion regulation and because much of the work contained in this analysis is based on facility expansion measures which are subject to error, a second examination is conducted using a commonly accepted facility measure. This examination is discussed in the following section.

Dichotomous Expansion Variables. Several health economics researchers have employed a series of dichotomous, or dummy, variables in their efforts to capture the effects of facility structure on numerous aspects of the hospital. References to these examples are contained in Chapters II and IV. A similar approach is applied here to cost change information for the 68 FACX hospitals for the one-year period following the 1971 facilities expansion.

The FACX and RFACX variables are replaced by dummy variables reflecting Berry's classification scheme which was discussed earlier.[14] Three groups of facilities were created for purposes of this analysis. These include:

BASIC - the facilities almost all hospitals have and which include such facilities as emergency and operating rooms, and X-ray treatment.

QUALEN - the "quality enhancing" facilities which tend to improve the quality of existing care within a hospital. Examples of facilities in this group include blood banks and premature nurseries.

COMPLEX - the facilities which tend to "expand the scope of services offered by a hospital and to add to the capacity to treat a wide variety of ailments."[15] An example of this type of facility would be an intensive care unit.

A value of 1 is assigned to the BASIC variable if a hospital added a "basic" facility and 0 if it did not. Similarly, a 1 is assigned to the QUALEN or COMPLEX variables if a hospital added a facility falling in either of these two categories and a zero if it did not. The facilities included in each expansion classification are shown in Table XX, which is included in the appendix to this study.

A continuous variable, EXPS, is also added to the regression model to reflect the number of facilities added by expansion in 1971. It is expected, ceteris paribus, that the more facilities added during expansion, the greater the impact upon costs over time.

The relationship of the three facility expansion classification dummy variables to cost is also expected to be positive. Further, to the extent that complicated facility expansions have a greater impact upon costs than do more simple expansions, the regression coefficient of COMPLEX is expected to be higher than either QUALEN or BASIC.

Zero-order correlation coefficients for this equation are shown in Table XIX. Potential for multicollinearity problems does not appear to be major among the included variables, especially among the new expansion variables.

The adjusted regression equation for this model is shown in Equation (25).

TABLE XIX

ZERO-ORDER CORRELATION COEFFICIENTS: FACILITIES EXPANSION/
ONE-YEAR PERIOD/DICHOTOMOUS EXPANSION VARIABLES

	BASIC*	QUALEN*	COMPLEX*	EXPS*	BEDX*	OCC	PATDAYS	PADC	AVWAGE	GPBED*	SPBED*	INCOME	PRESS	HSIZE	LOS	AC71
BASIC*	1.00	-.38	-.36	.10	.05	-.05	.10	.17	.10	-.12	.22	-.08	-.06	-.04	.20	.20
QUALEN*		1.00	-.20	.36	.09	.01	-.01	.04	-.11	-.03	-.10	.00	.12	.00	-.04	-.09
COMPLEX*			1.00	.31	-.04	.00	.06	-.07	.13	.08	-.03	.14	-.19	.06	-.02	.02
EXPS*				1.00	.08	.05	.02	.00	.11	.05	-.04	-.03	-.14	.15	.20	.08
BEDX*					1.00	.05	.30	.14	-.04	-.24	.39	.14	-.23	.01	.36	.10
OCC						1.00	.40	-.10	.12	-.13	.23	.09	-.06	.10	.13	.06
PATDAYS							1.00	.33	.52	-.62	.71	.46	-.17	.11	.43	.50
PADC								1.00	.12	-.47	.48	.32	.04	.12	.09	.70
AVWAGE									1.00	-.42	.43	.39	.13	.25	.32	.59
GPBED*										1.00	-.68	-.33	.05	-.33	-.32	-.59
SPBED*											1.00	.42	-.19	.15	.45	.66
INCOME												1.00	.14	.08	.19	.46
PRESS													1.00	.07	-.22	.11
HSIZE														1.00	-.09	.29
LOS															1.00	.29

*Variables in non-log form.
Number of observations: 68.

$$\hat{LAC72} = \underset{(1.17)}{-7.032} + \underset{(0.37)}{0.012}\ EXPS + \underset{(1.34)}{0.087}\ BASIC + \underset{(0.38)}{0.028}\ QUALEN + \underset{(0.43)}{0.028}\ COMPLEX$$

$$- \underset{(0.49)}{0.002}\ BEDX - \underset{(0.03)}{0.004}\ LOCC - \underset{(0.72)}{0.034}\ LPATDAYS + \underset{(8.90)}{0.946}\ LPADC$$

$$+ \underset{(11.40)}{0.869}\ LAVWAGE + \underset{(1.15)}{1.452}\ GPBED + \underset{(0.66)}{0.155}\ SPBED + \underset{(1.95)}{0.361}\ LINCOME$$

$$- \underset{(1.21)}{0.167}\ LPRESS + \underset{(0.53)}{0.163}\ LHSIZE + \underset{(0.56)}{0.079}\ LLOS + \underset{(4.95)}{0.504}\ LAC71. \quad (25)$$

$$F = 29.02 \qquad R^2 = .9080$$

Expansions in facilities as measured by a series of dichotomous variables suggest, as did the facility expansion index variables, that facility expansions exert little systematic effect upon hospital costs over time. All four of the expansion variables were positive in their relationship to costs, as expected, although the asymptotic standard error exceeded the adjusted regression coefficient in every case except the BASIC measure. It is somewhat surprising that the BASIC expansion variable tended to exert a greater influence on cost over time than did either the QUALEN or COMPLEX variables, although it must be remembered that none of the three coefficients were statistically different than zero.

The application of a similar model to cost increases over the two-year period following facility expansion, which is not reported here, produced results very similar to those shown in Equation (25). An examination of three-year cost increases with this model was not conducted.

In general, it appears that, regardless of the facility expansion measure employed, new facilities do little to systematically affect costs over time. The implications for hospital regulation policy of this and other findings are considered in the concluding chapter of the study.

Summary

This chapter has specified and estimated a cost inflation model for a group of 37 hospitals which expanded beds in 1971 and for a group of 68 hospitals which added new facilities in 1971. The major concern of this study has been to determine whether or not expansions in beds and/or facilities systematically affected costs in the hospitals over time.

To test the hypothesis that expansions do systematically affect costs, the asymptotic standard error for each regression coefficient had to be calculated--due to the inherent characteristics of the partial adjustment model which is used--and the estimators themselves adjusted for the implicit speed of adjustment.

Results of the empirical tests suggest that beds expansion does in fact tend to drive up hospital costs during the first year following the expansion. This is the composite result of the positive influence of the absolute number of beds added (which is significant at the .11 level) and the negative effect of the relative impact of new beds. The combined effect of these two forces serves to drive up cost per patient day in the average expanding hospital by about 4.1 percent during the first year.

The effect of new beds in explaining cost increases over the two- and three-year periods following expansion is insignificant--both statistically and vis-a-vis other forces which are at work.

Facility expansions appear not to systematically explain variations in cost inflation over any of the three length periods following expansion. This was true for both index variables used to measure facility expansions, although the statistical importance of both measures appeared to be improving over time.

A common approach of identifying facility expansions via a series of dichotomous variables was also employed to test the sensitivity of the results to the facility expansion variable used. The results of the latter approach were very similar to the results reported for the index expansion variables--facility expansions had little systematic explanatory power.

The implication of the various findings above for hospital regulation policy is one of the major subjects for the concluding chapter which follows.

FOOTNOTES

[1]The problem arises because several counties included in the analysis had no specialists in 1973. The natural log of 0 is $-\infty$ and cannot be computed in the least squares regression.

[2]"r" restricted coefficients are for the D_i and S_i parameters, and the two additional restricted coefficients are for λ and for a, the coefficient for the constant A.

[3]Jan Kmenta, Elements of Econometrics (New York, 1971), p. 443.

[4]Ibid.

[5]Ibid., p. 444.

[6]American Hospital Association, Guide to the Health Care Field (Chicago, 1971, 1972), Lists of Health Care Institutions.

[7]Unfortunately, 1974 information is not available for one of the BEDX hospitals and for two of the FACX hospitals.

[8]J. Johnston, Econometric Methods, p. 160.

[9]See Donald Farrar and Robert Glauber, "Multicollinearity in Regression Analysis: The Problem Revisited," Review of Economics and Statistics, XLIX (1967), p. 98 for a discussion of these general rules.

[10]It should be noted that, asymptotically, the ratio of the estimators to the standard errors is normally distributed, and that therefore there are no adjustments in the standard errors for degrees of freedom. The author appreciates the assistance of Dr. John Rea on this point.

[11]See pages 62-63 and Table VII for average characteristics of hospitals expanding beds.

[12]This and subsequent percentage comparisons assumed a 1971 average cost in the typical hospital of $79.31 (which was typical for the hospitals in the BEDX group).

[13]Hales, p. 69, Table II.

[14]Berry, "On Grouping Hospitals."

[15]Ibid., p. 8.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Introduction

This final chapter has two tasks. First, the overall study is synthesized, with the hospital regulation process serving as the focal point. The contribution of each of the preceding chapters in answering the question, "Can hospital costs be affected by regulation of hospital expansions?" is reconsidered. Second, this chapter concludes by assessing the implications of the study's empirical findings for hospital regulation policy. Limitations of the present analysis and possibilities for further investigation are included in this discussion.

Summary

Hospital expansion regulation, one of the major state and federal public efforts against hospital cost inflation, assumes that certain hospital expansions affect costs differently than do other expansions. The regulation process is predicated upon an ability to differentiate ex ante between those expansions which will have deleterious effects upon hospital costs and those which will have socially acceptable impacts upon costs. The technical requirements for this type of regulation process have grown steadily from their early introduction in the Hill-Burton legislation.

If hospital expansion regulation is to be effective in slowing hospital cost inflation, the basic relationship between expansions and cost increases must be understood. On the one hand, if certain expansions are to be distinguished from others in the regulation process, the relationship between specific expansions and cost increases must be systematic, that is, predictable. The health planner must be able to know that a certain type of expansion in a certain type of hospital consistently produces a well-defined impact upon costs. On the other hand, if the effect of expansions on cost is systematic but small, the planner will meet with little success in slowing cost inflation through expansion regulation, since other more significant forces will be at work to raise costs in the hospital.

In response to these unresolved issues, this study has sought to answer three specific questions. First, does the addition of beds in some hospitals affect cost differently than an addition of beds in other hospitals? Second, does the addition of certain facilities systematically affect hospital costs over time? And last, if expansions do affect costs, are their effects important vis-a-vis other forces at work in the hospital?

Chapter II discussed the basic economics of the hospital. There it was presented that if expansions systematically affect costs, it is through their impact upon hospital cost curves. New beds increase the "scale of plant" along the existing long-run cost schedule in the hospital. New facilities change the basic structure of the hospital and produce new long-run cost conditions in the hospital.

Chapter III set the backdrop for the relative importance question. Other forces in the hospital, broadly grouped under demand-pull and cost-push categories, were identified so that their effect on cost could be contrasted to the effect of expansion-related variables. Variables which had been used in previous studies to capture the effects of alternative inflation forces were identified in this discussion.

Chapters II and III were tied together conceptually in the partial adjustment model developed in Chapter IV. The basic tenets of this model include (1) an equilibrium level of average cost in the hospital which is determined by supply and demand conditions for the hospital, and (2) an adjustment process by which the gap between equilibrium and actual average cost in the hospital is partially closed over a given period of time. The identification of specific supply and demand variables makes the conceptual model developed one which could be estimated in the subsequent chapter.

Tentative answers to the three questions asked in this study were the product of the empirical testing conducted in Chapter V. The general findings were that beds expansions do have a net positive effect upon cost during the first year following expansion. It was also found that it does make a slight difference whether or not beds are added to a small or to a large hospital. Although the level of occupancy and patient use make no statistical difference in cost changes over the one-year period following expansion, cost decreases due to the relative effect of new beds can range from 0.1 to 0.3 percent for the hospitals included in this analysis.

None of these effects were detectable, however, in the two- and three-year periods following beds expansion.

Expansion of facilities shows no systematic relationship with cost increases over time. This is true for the one-, two- and three-year periods following expansion and for three different measures of facilities expansion.

For the one-year period in which beds expansion variables were significant, it appears that they were major forces in pushing up costs in the hospital studied. The average net beds expansion effect on costs was +4.1 percent over the period, while the next strongest force which was increasing hospital wages raised costs by 1.4 percent. In all subsequent periods, the relative importance of both beds and facilities expansions must be assumed negligible since neither set of expansion variables proved statistically significant in these periods.

Implications for Public Policy

The findings of this study do not look encouraging for the present attempts to control hospital cost inflation through regulation of hospital expansions. Costs do in fact rise over the very short period following beds expansion, due to the new beds, although it appears that there is little which differentiates impacts among various types of hospitals. To the extent that new beds are needed in an area, it makes little difference which hospitals expand.

Long-term cost control appears to be beyond the scope of expansion regulation at the present time. The effect of new beds or facilities could not statistically be detected in any lengthy period following expansion. It would appear, however, that if expansion regulation is to be continued, additional factors should be brought into the expansion review process. For example, on the basis of the evidence presented in this study, the probable impact that a new facility will have on the number of personnel utilized per patient or on the average wage structure of the hospital should be examined--especially since these parameters appear to have long-lasting effects on costs.

It would seem that the recent shift in public emphasis toward "rate review" may well be an appropriate action. An efficacious rate setting mechanism could possibly span many forces which are at work in the hospital to drive up costs, although this would require major improvements in the present understanding of cost determination in the hospital industry.

As with any study, the findings of this endeavor should not be viewed uncritically. The study has several limitations which should be noted in present and future interpretations.

One limitation to the present study is that accounting practices followed by hospitals may not adequately be reflected by the cost information used here. Aggregate data such as that presented in the Guide Issue cannot provide as detailed hospital data as would be preferred for the analysis of individual hospitals. Similarly, differences in accounting practices among the various hospitals are not noted in the Guide Issue data.

A second limitation to this study is the use of the county as a proxy for hospital market area. Hospital discharge information suggests that the geographical distribution of patients using a hospital may vary according to the role of the hospital in the regional medical system[1] and to the referral patterns of area physicians.[2] Any study of hospital costs and their changes could be improved by employing the economic and demographic information for the specific market area of each hospital studied, although the increased research costs of improved market delineations may be significant.

This and similar studies are also limited by the fact that hospital cost curves should be interpreted over only a limited range of output.[3] This is especially true of a multi-product firm such as the hospital. To minimize the effect of this limitation, the cost analysis used by hospital regulators should be reviewed periodically to maintain its reliability.

Lastly in way of limitations, this study and its results pertain only to expansions in short-term general hospitals in Wisconsin, Iowa, and Minnesota. Application of the model developed here to hospitals in other states could produce different results than those reported above. Thus, the conclusions concerning the impact of new beds and facilities upon costs which are suggested here should be considered as only tentative until tested in other situations.

While there were limitations to the present study, there were also several points of interest raised which should receive future study. For example, the relationship between average length of stay and costs in the expansion hospitals suggested that length of stay is not necessarily associated with the complexity of the cases being treated--average cost decreased with longer lengths of stay. Also, a relative abundance of beds in expansion hospital counties had an unexpected positive influence on costs. Of most specific interest to this study, the growing statistical significance of the facilities expansion variables should be further tested when 1975 hospital data become available.

It is probably most appropriate to conclude this study with a note concerning the study's nature. This effort has not been a cost-effectiveness analysis of expansion regulation. Data do not exist to statistically analyze the effects of current programs in slowing hospital cost inflation. This study has examined the relationship between cost increases and expansions in order to make inferences concerning the possibilities of controlling costs through expansion regulation. Finding that this relationship was generally not systematic over time, it has been suggested that expansion regulation will not be especially efficacious as a cost-containment device.

This does not necessarily mean that expansion regulation should be abandoned. This study has been limited to only the cost control aspects of the regulation mechanism. To the extent that expansion regulation accomplishes other purposes such as redistribution of medical services and improved access for certain populations, the tool may very well be useful and appropriate.

Further, the nature of this study has been such that economic theory has been applied--rather than conceived and verified. Hopefully, as a result of this study, health planners will have a sense of not only what forces are working in the hospital to drive up costs but also how strong these forces are. Overall, the direction of this study has been intended to further August Lösch's early goal for regional science that

> Comparison now has to be drawn no longer to test the theory, but to test reality! Now it must be determined whether reality

is rational. In any case this, and not verification of theory, is the purpose of the following investigations. In undertaking them I have attempted more to suggest how strong the forces of order really are than to intensify, by enumerating contradictory case, the discouraging impression of chaos under which we have suffered too long. If we are unable to alter such cases, they arouse only bitterness and despair. It is my desire to reinforce in my readers the conviction that a rational economic order is not only conceivable, but realizable.[4]

FOOTNOTES

[1]Lave and Lave, "The Extent of Role Differentiation."

[2]Pierre de Vise, _Misused and Misplaced Hospitals and Doctors: A Locational Analysis of the Urban Health Care Crisis_ (Washington, D.C., 1973), p. 18.

[3]Lave and Lave, "Hospital Cost Functions," p. 379.

[4]August Lösch, _The Economics of Location_, tr. William Woglom and Wolfgang Stolper (New Haven, 1954), p. ii.

BIBLIOGRAPHY

American Hospital Association 1973 Guide to the Health Care Field. Chicago: The American Hospital Association, 1973.

American Hospital Association Hospital Statistics, 1971. Chicago: The American Hospital Association, 1971.

American Hospital Assocoation Hospital Statistics, 1974. Chicago: The American Hospital Association, 1974.

Anderson, James. "Causal Model of a Health Services System." Health Services Research, VII (1972), pp. 23-42.

Bailey, Richard. "Economies of Scale in Medical Practice." Ed. Herbert E. Klarman. Empirical Studies in Health Economics. Baltimore: The Johns Hopkins Press, 1970, pp. 255-273.

Berki, Sylvester E. Hospital Economics. Lexington, Mass.: Lexington Books, 1972.

Berki, Sylvester E. "The Pricing of Hospital Services." Ed. Selma Mushkin. Public Prices for Public Products. Washington, D.C.: The Urban Institute, 1972, pp. 351-369.

Berry, Brian, and William Garrison. "Recent Developments of Central-Place Theory." Papers and Proceedings of the Regional Science Association, IV (1958), pp. 107-120.

Berry, Ralph. "On Grouping Hospitals for Economic Analysis." Inquiry, X (December, 1973), pp. 5-12.

________. "Product Heterogeneity and Hospital Cost Analysis." Inquiry, VII (March, 1970), pp. 67-75.

________. "Returns to Scale in the Production of Hospital Services." Health Services Research, II (Summer, 1967), pp. 123-139.

Carr, W. John. "Economic Efficiency in the Allocation of Hospital Resources." Empirical Studies in Health Economics. Ed. Herbert E. Klarman. Baltimore: The Johns Hopkins Press, 1970.

________, and Paul F. Feldstein. "The Relationship of Cost to Hospital Size." Inquiry, IV (June, 1967), pp. 45-65.

Cohen, Harold A. "Variations in Cost Among Hospitals of Different Sizes." The Southern Economic Journal, XXXIII (January, 1967), pp. 355-366.

________. "Hospital Cost Curves with Emphasis on Measuring Patient Care Output." Empirical Studies in Health Economics. Ed. Herbert E. Klarman. Baltimore: The Johns Hopkins Press, 1970, pp. 279-294.

Davis, Karen. "Economic Theories of Behavior in Nonprofit Hospitals." Economic and Business Bulletin, XXIV (Winter, 1972), pp. 1-13.

________. "Relationship of Hospital Prices to Costs." Applied Economics, IV (1971), pp. 115-125.

________. Rising Hospital Costs: Possible Causes and Cures. Reprint 262. Washington, D.C.: The Brookings Institution 1973.

________. "Theories of Hospital Inflation. Some Empirical Evidence." The Journal of Human Resources, VIII (Spring, 1973), pp. 181-201.

________, and Richard Fosters. Community Hospitals: Inflation in the Pre-Medicaid Period. Social Security Administration, Office of Research and Statistics Research Report No. 41. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1972.

________, and Louise B. Russell. "The Substitution of Hospital Outpatient Care for Inpatient Care." Review of Economics and Statistics, LIV (May, 1972), pp. 109-120.

de Vise, Pierre. Misused and Misplaced Hospitals and Doctors: A Locational Analysis of the Urban Health Care Crisis. Washington, D.C.: Association of American Geographers, 1973.

Elnicki, Richard. "Hospital Productivity, Service Intensity, and Costs." Health Services Research, IX (Winter, 1974), pp. 270-292.

Farrar, Donald, and Robert Glauber. "Multicollinearity in Regression Analysis: The Problem Revisited." Review of Economics and Statistics, XLIX (1967), pp. 92-107.

Feldstein, Martin. "An Econometric Model of the Medicare System." The Quarterly Journal of Economics, LXXXV (February, 1971), pp. 1-20.

________. Economic Analysis for Health Service Efficiency. Chicago: Markham Press, 1968.

________. "Hospital Cost Inflation: A Study of Nonprofit Price Dynamics." American Economic Review, LXI (December, 1971), pp. 853-872.

________. The Rising Cost of Hospital Care. Washington, D.C.: Information Resources Press, 1971.

Feldstein, Paul. An Empirical Investigation of the Marginal Cost of Hospital Services. Chicago: University of Chicago, 1961.

________, and J. Gorman. "Predicting Hospital Utilization: An Evaluation of Three Approaches." Inquiry, II (June, 1965), pp. 13-36.

________, and Sander Kelman. "An Econometric Model of the Medical Care Sector." Empirical Studies in Health Economics. Ed. Herbert E. Klarman. Baltimore: The Johns Hopkins Press, 1970, pp. 171-190.

Ferguson, C. E. Microeconomic Theory. 3rd. ed. Homewood, Ill.: Richard D. Irwin, Inc., 1972.

Francisco, Edgar W. "Analysis of Cost Variations Among Short-Term General Hospitals." Empirical Studies in Health Economics. Ed. Herbert E. Klarman. Baltimore: The Johns Hopkins Press, 1970, pp. 321-334.

Fuchs, Victor R., ed. Essays in the Economics of Health and Medical Care. New York: National Bureau of Economic Research, 1972.

Ginsburg, Paul. "Resource Allocation in the Hospital Industry: The Role of Capital Financing." Social Security Bulletin, XXXV (October, 1972), pp. 20-30.

Greenfield, Harry. Hospital Efficiency and Public Policy. New York: Praeger Publishers, 1973.

Hales, Wayne. "An Analysis of the Effects of Competitive Markets on Hospital Costs in Oklahoma." (Unpublished Ph.D. dissertation, Oklahoma State University, 1974.)

Havighurst, Clark. Public Utility Regulation for Hospitals. Washington, D.C.: American Enterprise Institute, 1973.

Ingbar, Mary Lee. "Controlling the Expansion of Health Care Facilities in a State: The Prediction Dilemma." Proceedings of the Public Health Conference on Records and Statistics. Washington, D.C.: U.S. Department of Health, Education, and Welfare, Public Health Service, 1972, pp. 338-343.

________, and Lester Taylor. Hospital Costs in Massachusetts. Cambridge: Harvard University Press, 1968.

Jacobs, Philip. "A Survey of Economic Models of Hospitals." Inquiry, XI (June, 1974), pp. 83-97.

Jeffers, James R., and Calvin D. Siebert. "Measurement of Hospital Cost Variation: Case Mix, Service Intensity, and Input Productivity Factors." Health Services Research, IX (Winter, 1974), pp. 293-307.

Johnston, J. Econometric Methods. 2nd ed. New York: McGraw-Hill, Inc., 1972.

________. Statistical Cost Analysis. New York: McGraw-Hill Book Company, 1960.

Kaitz, Edward M. Pricing Policy and Cost Behavior in the Hospital Industry. New York: Frederick A. Praeger, 1968.

Klarman, Herbert. "Approaches to Moderating the Increases in Medical Care Costs." Medical Care, VII (1969), pp. 175-190.

________, ed. Empirical Studies in Health Economics. Baltimore: The Johns Hopkins Press, 1970.

________. "Major Public Initiatives in Health Care." The Public Interest, XXXIV (Winter, 1974), pp. 106-123.

Kmenta, Jan. Elements of Econometrics. New York: The Macmillan Company, 1971.

Lave, Judith, and Lester Lave. "Economic Analysis for Health Service Efficiency: A Review Article." Applied Economics, I (1970), pp. 293-305.

________. "Estimated Cost Functions for Pennsylvania Hospitals." Inquiry, VII (June, 1970), pp. 3-14.

________. "The Extent of Role Differentiation Among Hospitals." Health Services Research, VI (Spring, 1971), pp. 6-44.

________. "Hospital Cost Functions." American Economic Review, LX (June, 1970), pp. 379-395.

Lee, A. James, and Burton Weisbrod. Collective Goods and the Voluntary Sector: The Case of the Hospital Industry. Madison, Wis.: The University of Wisconsin, 1974.

Lee, Maw Lin. "A Conspicuous Production Theory of Hospital Behavior." The Southern Economic Journal, XXXVIII (July, 1971), pp. 48-58.

Leftwich, Richard. The Price System and Resource Allocation. 5th ed. Hinsdale, Ill.: The Dryden Press, 1973.

Lösch, August. The Economics of Location. Tr. William Woglom and Wolfgang Stolper. New Haven: Yale University Press, 1954.

Michigan Department of Social Services. Rising Medical Costs in Michigan: The Scope of the Problem and the Effectiveness of Current Controls. Lansing: Michigan Department of Social Services, 1973.

Muller, Charlotte F., and Paul Worthington. "Factors Entering into Capital Decisions of Hospitals." Empirical Studies in Health Economics. Ed. Herbert E. Klarman. Baltimore: The Johns Hopkins Press, 1970, pp. 399-415.

Newhouse, Joseph P. "A Model of Physician Pricing." The Southern Economic Journal, XXXVII (October, 1970), pp. 174-183.

________. "Toward a Theory of Nonprofit Institutions." American Economic Review, LX (May, 1970), pp. 64-74.

Olsson, Gunnar. "Central Place Systems, Spatial Interaction, and Stochastic Processes." Urban Economics. Ed. William Leahy, et al. New York: The Free Press, 1970, pp. 177-215.

Pauly, Mark, and David F. Drake. "Effect of Third-Party Method of Reimbursement on Hospital Performance." Empirical Studies in Health Economics. Ed. Herbert E. Klarman. Baltimore: The Johns Hopkins Press, 1970, pp. 297-314.

Pauly, Mark, and Michael Redisch. "The Not-for-Profit Hospital as a Physicians' Cooperative." American Economic Review, LXIII (March, 1973), pp. 87-100.

Pettengill, Julian. "The Financial Position of Private Community Hospitals, 1961-1971." Social Security Bulletin, XXXVI (November, 1973), pp. 3-19.

Reder, M. W. "Economic Theory and Nonprofit Enterprise: Some Problems in the Economics of Hospitals." American Economic Review, LV (May, 1965), pp. 472-480.

Rice, Dorothy P., and Barbara S. Cooper. "National Health Expenditures, 1929-71." Social Security Bulletin, XXXV (January, 1972), pp. 3-18.

Ro, Kong-Kyun. "Patient Characteristics, Hospital Characteristics and Hospital Use." Medical Care, VII (July-August, 1969), pp. 295-312.

Roemer, Milton, A. Taher Moustafa, and Carl Hopkins. "A Proposed Hospital Quality Index: Hospital Death Rates Adjusted for Case Severity." Health Services Research, III (Summer, 1968), pp. 96-118.

Rosenthal, Gerald. The Demand for General Hospital Facilities. Chicago: American Hospital Association, 1964).

Ruchlin, Hirsch and Irving Leveson. "Measuring Hospital Productivity." Health Services Research, IX (Winter, 1974), pp. 308-323.

Salkever, David. "A Microeconomic Study of Hospital Cost Inflation." Journal of Political Economy, LXXX (1972), pp. 1144-1166.

________. "Studies in the Economics of Hospital Costs." (Unpublished Ph.D. dissertation, Harvard University, 1970.)

Simonson, John. "The Determinants of Changes in the Allocation of Hospital Service Capacity: A Study in Policy Theory." (Unpublished Ph.D. dissertation, University of Wisconsin, 1972.)

Somers, A. R. Hospital Regulation: The Dilemma of Public Policy. Princeton, N.J.: Princeton University Press, 1969.

Somers, Herman M., and Anne Somers. Doctors, Patients and Health Insurance. Washington, D.C.: The Brookings Institution, 1961.

Taylor, Lester. "The Demand for Electricity: A Survey." The Bell Journal of Economics, VI (Spring, 1975), pp. 74-110.

U.S. Department of Health, Education, and Welfare. An Analysis of State and Regional Health Regulations. Health Resources Studies No. 75-611. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1975.

U.S. Department of Health, Education, and Welfare. Health Planning and Resources Development Act of 1974. Health Resources Administration No. 75-14015. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1975.

Weisbrod, Burton. "Collective-Consumption Services of Individual Consumption Goods." Quarterly Journal of Economics, LXXVII (August, 1964), pp. 471-477.

Wisconsin Department of Administration. Wisconsin State Plan for Hospitals and Medical Facilities, 1972-1973. Madison, Wis.: Wisconsin Department of Administration, 1972.

APPENDIXES

TABLE XX

FACILITY EXPANSION CODES AND DICHOTOMOUS VARIABLE CLASSIFICATIONS

Expansion Code	Facility	Dichotomous Variable Classification Group
1	Postoperative Recovery Room	QUALEN
2	Intensive Care Unit	COMPLEX
3	Intensive Cardiac Care Unit	COMPLEX
4	Open Heart Surgery Facility	COMPLEX
7	X-Ray Therapy	BASIC
8	Cobalt Therapy	COMPLEX
9	Radium Therapy	COMPLEX
10	Diagnostic Radioisotope	COMPLEX
11	Therapeutic Radioisotope	COMPLEX
12	Histopathology Laboratory	BASIC
13	Organ Bank	COMPLEX
14	Blood Bank	QUALEN
15	Electroencephalography	COMPLEX
16	Inhalation Therapy	QUALEN
17	Premature Nursery	QUALEN
20	Inpatient Renal Dialysis	COMPLEX
22	Burn Care Unit	COMPLEX
23	Physican Therapy	COMPLEX
24	Occupational Therapy	BASIC
27	Psychiatric Inpatient Unit	COMPLEX
30	Psychiatric Emergency Service	COMPLEX
33	Organized Outpatient Department	BASIC
34	Emergency Department	BASIC

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