A statistical analysis of the cost of care in rural hospitals with policy implications
by Larry Evan Finch

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Applied Economics
Montana State University

Abstract:
The average cost per patient day of hospital care in the United States has risen more than 1,000 percent since 1950. This compares to an increase of 125 percent in the general level of consumer prices over the same period. This rapid rise in the cost of health care has focused legislative attention on the helath care delivery system and has prompted passage of the National Health Planning and Resource Development Act of 1974, which provides for health care planning by public sector agencies at the state and local level. In conjunction with the Act a set of National Guidelines, issued in August, 1977, recommend a maximum of four hospital beds per 1000 population and a minimum occupancy rate of eighty percent in hospitals in order to promote efficiency.

The guidelines were established partly on the basis of the results of past empirical research which includes studies of strictly urban or urban and rural hospitals. No past studies have concentrated exclusively on rural hospitals. This study attempts to fill that gap in that only rural hospitals are examined and analyzed. It is hoped that the results of this study can be compared with the results of past efforts in order to determine if the policy implications suggested in the above guidelines are equally applicable to rural as well as urban hospitals.

In particular, this study attempts to estimate the extent to which savings can be realized through a program of consolidation in rural hospitals. The least-cost size and occupancy rate are estimated in order to determine the extent to which increasing occupancy rates and scale economies reduce average costs per patient day in rural hospitals. The savings that would arise from utilizing a system of hospitals of least-cost size operating at the least-cost occupancy rate are then estimated. The benefits that result can then be weighed by planners against the increase costs (ambulance service, risk, etc.) that arise as a consequence of consolidation in order to determine if the existing structure of rural health care delivery warrants change. The study also examines the relative costliness of services offered in rural hospitals and attempts to determine how costs vary among hospitals of different types.

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Approved:

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MONTANA STATE UNIVERSITY
Bozeman, Montana

May, 1980

ACKNOWLEDGEMENTS

Foremost, I wish to thank my thesis advisor, Dr. Jon Christianson for guiding me through this period of incipience and for offering me the opportunity to work in the field of health economics. Thanks, also, are due to John Marsh, (committee member), Oscar Burt (committee member), Douglas Young and Robert Chew for much needed help in regards to the statistical technique employed throughout the analysis. Finally, I would like to take this opportunity to thank the faculty, staff and graduate students of the Department of Agricultural Economics and Economics (1978-1980) for providing an ambiance most conducive to the completion of this thesis.

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ABSTRACT

The average cost per patient day of hospital care in the United States has risen more than 1,000 percent since 1950. This compares to an increase of 125 percent in the general level of consumer prices over the same period. This rapid rise in the cost of health care has focused legislative attention on the helath care delivery system and has prompted passage of the National Health Planning and Resource Development Act of 1974, which provides for health care planning by public sector agencies at the state and local level. In conjunction with the Act a set of National Guidelines, issued in August, 1977, recommend a maximum of four hospital beds per 1000 population and a minimum occupancy rate of eighty percent in hospitals in order to promote efficiency.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

Introduction and Objectives:

The average cost per patient day of hospital care in the United States rose from $15.62 in 1950 to $175.08 in 1976 [1]. This rise of more than 1,000 percent compares to an increase of 125 percent in the general level of consumer prices over the same period [2]. The sharp rise in the cost of hospital services has emphasized the importance of gaining a better understanding of the determinants of hospital costs. The purpose of this thesis is to investigate the determinants of costs in rural hospitals. Specifically, the major objectives of the research are:

1. To ascertain which of the services offered by rural hospitals are associated with high costs and which are associated with low costs.
2. To determine how costs vary among rural hospitals of different types.
3. To analyze the relationship between occupancy rates and the average cost of services in rural hospitals.
4. To investigate the presence or absence of economies or diseconomies of scale in small, rural hospitals.

In addition, the research will provide information on the differences in costs between public and private institutions and between for-profit and not-for-profit institutions.

This study is different from previous hospital cost studies in that it concentrates exclusively on rural hospitals. To further clarify the nature of the problem, the next section presents a brief history of the development of the rural hospital. Section III discusses some of the hypotheses explaining the rapid increase in hospital costs since 1950; and Section IV reviews recent regulatory and legislative efforts to contain or reduce costs.

Historical Development

The development of rural community hospitals has lagged behind that of larger, more urban institutions. Until about 1930 the development and financing of rural, community hospitals was largely dependent upon the initiative of the local populace. Rural, agricultural communities tended to be less affluent than urban districts, and usually found themselves lacking the necessary funds to finance the construction of hospital facilities. In the early 1930's only fourteen hospitals (funded by the Commonwealth Fund) were built in rural communities [3].

A further hindrance to the development of rural community hospitals during this period was uncertainty concerning the supply of qualified personnel to staff rural facilities. As a result of the Flexner Report, published in 1910, the number of certified medical schools fell from 162 in 1906 to 69 in 1944, severely curtailing the supply of licensed surgeons and physicians [4]. This reduction in supply was particularly hard felt in rural areas, which were viewed as relatively unattractive by medical practitioners. It was not until 1945 that the trend towards reducing the supply of manpower initiated by the Flexner Report was reversed.

During World War II a limited amount of federal funding for hospital construction was provided by the Community Facilities Act, but it wasn't until after the war that involvement on the part of the federal government in the construction of rural health services became significant. The National Hospital Survey and Construction (Hill-Burton) Act of 1946 provided grants to the states for the construction of government and voluntary non-profit facilities in those areas of "greatest need", which generally meant rural areas. The disparity in bed supply between rural and urban areas was largely eliminated within twenty years after passage of the Hill-Burton Act [5]. By 1966 over $2.5 billion of federal funds had been used to construct more than 350,000 additional hospital and nursing home beds, the bulk in rural areas [6].

The NHSCA did not provide for a coordinated system of comprehensive health planning and consequently much hospital construction since its passage has occurred in a rather haphazard manner. Communities may have been provided funding for the construction of facilities with little regard to the long-run appropriateness of the type of facility being built. This can be partly justified on the grounds that at the time transportation difficulties required each rural community to provide its own hospital services. With the development of the Federal Interstate Highway System and increased availability and use of air transport systems this problem became less important. Consequently, there has been a shift away from use of the local hospital to use of larger, urban hospitals, which are sometimes viewed as providing a higher quality of care. This has contributed to reductions in the traditionally low occupancy rates of rural hospitals, and low occupancy rates are one of several reasons cited for the current high cost of hospital services. The next section considers several of the more popular hypotheses regarding the rapid rise in the cost of these services over the past few decades.

Theories of Hospital Cost Inflation

In an article addressing the temporal changes in hospital costs, Karen Davis explains the reasons for hospital cost inflation and their importance for devising effective policy:

> ". . . If hospital inflation is largely a consequence of increasing demand without increases in supply, an expansion of hospital beds may be warranted. If the inflation is a labor cost-push inflation, attempts to curtail labor costs through wage guidelines or control may be the appropriate policy. If the inflation is induced by certain types of insurance coverage, a restructuring of insurance coverage

may be called for. If the inflation is induced by inefficiencies in the hospital market, structural reform of the industry may be a desired course of action. If the inflation is the result of advances in medical technology, inflation may simply be a necessary price of improvement in health" [7].

In a similar fashion the President's Council on Wage and Price Stability is concerned about whether the persistent rise in hospital costs is attributable to one or more "one-shot" developments, or instead is explained by the basic structure of the industry. They note that the distinction

". . . is crucial to public policy formulation because a one-shot explanation could lead either to complaisance, if the cost driving phenomenon is viewed as behind us, or to a remedy geared to one particular aspect of the problem if the one-shot cause is viewed as ongoing. On the other hand, if the source of inflation is inherent in the basic structure of the hospital care industry, then nothing short of fundamental reforms or alteration of this structure will cause the inflationary pressure to abate" [8].

Theories of cost inflation are usually formulated in terms of "demand-pull" or "cost-push" inflation. There is evidence that both of these kinds of inflation may be operating in the hospital sector today.

On the demand-pull side it is clear that costs began to noticably rise after the introduction of Medicare in 1966 [9]. Prior to the passage of this piece of legislation medical services to the elderly were very costly. After retiring, many individuals, no longer entitled to the employee benefits of inexpensive group medical insurance (paid in part by their employers) and unable to afford the more expensive individual insurance policies, simply did not have the means of acquiring medical care. After the introduction of Medicare the cost of health services to these individuals was reduced considerably resulting in a substantially increased demand. In 1975 government payments accounted for about 44.5 percent of total hospital revenues [10].

Also applying pressure on the demand-pull side has been the development and increased use of commercial insurance. The year 1929 brought the initial development of general hospital insurance on a community basis with the introduction of Blue Cross. Ten years later state medical societies began to sponsor Blue Shield insurance. Then in the early 1940's private commercial insurance companies began to offer a variety of coverage programs to individuals. During the post World War II period, fringe benefits through collective bargaining and the growth of union-management health and welfare funds provided for a large expansion in the purchase of voluntary health insurance via group plans. This form of financing has grown from covering 29.3 percent of all hospital costs in 1950 to 43.6 percent in 1975 [11].

It has been argued that this tremendous increase in insurance coverage induces an increase in the demand for higher quality services and more lavish amenities, which generates higher costs [12]. It may be safe to conjecture, however, that the impact of insurance is not as strongly felt when considering rural hospitals exclusively. Rural workers are not enrolled as easily in an insurance program as are urban workers, who have access to large, employment-related, group plans. This means that rural residents more frequently purchase the more costly, and perhaps less comprehensive, single-buyer type of insurance policy or go without insurance. Therefore one might expect demand in rural areas to be less stimulated by the introduction of comprehensive insurance than was demand in urban areas.

On the cost-push side many analysts point to the large increase in hospital wages that has occurred in the post-Medicare period as a reason for hospital cost inflation [13]. They cite the development of stronger collective bargaining and the application of minimum wage legislation to hospital employees as the means by which wages have been "catching up". From 1962 to 1966 total hospital payroll expenses increased at an average annual rate of 10.1 percent; from 1966-1968 the annual increase was 16.4 percent [14]. Furthermore, increases in average earnings per employee account for 90 percent of the increase while increases in the number of employees per day of care accounts for the remaining 10 percent [15].

Recent studies, however, indicate that wage increases are not a direct cause of hospital cost inflation [16], that the threat of unionization is not significant in raising wages [17], that hospitals do not pass on increased profits in the form of higher wages [18], and that if hospital wages had risen only at the rate of all non-farm sectors during 1955 and 1975, the average hospital cost rate increase still would have risen at 8.8 percent per year rather than the actual 9.9 percent [19]. However, increases in the use and prices of non-labor inputs do seem to be important factors in explaining increased costs [20].

Two additional theories of cost inflation can be found in the literature. The first is that hospitals compete for status. The result of this competition is an unnecessary and inefficient duplication of facilities [21]. In instances where the facilities are not used to capacity, their cost is passed on to consumers in the form of higher hospital charges. This problem is reduced somewhat in rural hospitals due to the fact that they generally are isolated from direct competition within the community. However, it could be important for rival, rural communities in that the status of the hospital is visual evidence of the condition of the community. The second theory is that hospitals receiving remuneration under a cost-plus reimbursement scheme have a strong incentive to raise costs. Karen Davis has shown that under the assumption of either profit maximization or output maximization subject to a budget constraint, it is not advantageous for hospitals to raise costs under a cost-plus reimbursement scheme unless approximately 95 percent of the patients are covered by insurance that reimburses at a rate of 105 percent of cost [22]. Given that only about 88 percent of all hospital costs currently are covered by insurance, cost-plus reimbursement schemes would not appear to be significant contributors to increasing costs.

In summary, the evidence suggests that the basic structure of the hospital industry, characterized by third-party methods of payments and nonprofit firms, is responsible for rising hospital costs. The President's Council on Wage and Price Stability (January, 1977) concludes "... that unless cost control discipline is extended through an altered incentive structure, the spiral of inflation in this sector of the economy will continue [23]". An understanding of factors contributing to variations in cost among hospitals may provide a clue to understanding these temporal changes in cost. The next section discusses the regulation that has been implemented to combat the spiral of hospital costs witnessed over the last two decades.

Regulation

Much of the regulation and planning within the hospital industry has been focused on making hospitals more efficient. Early attempts to increase the efficiency of the health care industry through planning occurred with the passage of the Comprehensive Health Planning Program (CHP) of 1966. This program called for the creation of "A" agencies--

statewide health planning agencies--and "B" agencies--areawide health planning agencies staffed primarily by local citizens. The agencies were established to oversee general health care systems and devise comprehensive facilities planning at the "A" level; and to coordinate the flow of resources and deal with specific planning problems at the "B" level.

The program had little effect initially due to considerable ambiguity regarding the agencies' authority and responsibilities, and because staff members were typically inexperienced and unqualified. But as planners began to perceive their functions more clearly they requested more authority and received it in the form of certificate-of-need legislation, A-95 review and comment procedures, and Section 1122 review and approval.

Certificate-of-need legislation provided local planners with the authority to review proposals for the construction of new facilities. Although the agencies couldn't actually veto a project, their recommendations often carried considerable weight in the decision process of those agencies responsible for allowing or denying construction. A-95 review and comment procedures directed planners to voice their opinions on the validity of applications for federal funds. Section 1122 of the Social Security Amendment of 1972 gave authority to the planning councils to review all capital expenditures planned by health providers that a) exceeded $100,000, b) changed bed capacity, or c) resulted in substantial change in service in which federal reimbursements were anticipated for depreciation and interest. These additional responsibilities were not enough to keep the program from failing, however. The reasons cited for failure of CHP are lack of funding, lack of expertise, limited regulatory power and easy provider dominance [24].

The National Health Planning and Resources Development Act of 1974 [PL 93-641] is the major piece of planning legislation influencing the health care industry today. At the federal level the Act calls for the establishment of a new Bureau of Health Planning and Development within the Health Resources Administration of the Department of Health, Education and Welfare, the creation of a National Health Planning Advisory Council, and the location of ten regional Technical Assistance Centers. At the state level the Act mandates the establishment of State Health Planning and Development Agencies and Statewide Health Coordinating Councils. At the local level the Act establishes 213 Health System Agencies. Each HSA has no less than ten members, sixty percent of whom are not providers. Providers constitute the remaining forty percent of the governing body. In addition, the proportion of individuals from non-metropolitan areas must parallel the non-metropolitan proportion of the population in the health services area.

The functions, duties and responsibilities of HSA's are very much the same as those of the planning councils under the CHP program. Operating under federal funding and monitoring, they are charged with data collection and analysis, plan development and implementation, certificate-of-need review, and a periodic review of the "appropriateness" of institutional health services. Again, actual power is restricted in that the only yes/no authority over health institutions is the right to approve or disapprove of projects funded under the Public Health Services Act and related programs. These projects comprise roughly ten percent of federal health spending. One of the problems with CHP, the lack of a set of standards or "appropriateness" criteria, has to a considerable extent been overcome in that the NHPRDA called for the issuance of a set of national guidelines by the Secretary of HEW by mid-1976. Such a set of guidelines has been developed and disseminated [25]. Included are the specifications that there should be no more than four hospital beds per 1000 population in an area and that hospitals should operate at an 80 percent occupancy rate. Rural hospitals frequently have more than four beds per 1000 population and generally operate at much less than an 80 percent occupancy rate. The implication is that there is currently an excess capacity of hospital beds in rural areas. This excess capacity, generally viewed as inefficient, could subject existing institutions to an appropriateness review based on the benefits and costs of a program of consolidation.

It is hoped that this thesis will provide information to health planners, community leaders, HSA representatives, administrators and physicians that will enable them to devise a lower cost system of health care provision without incurring any loss in quantity or quality of services. To be more specific, the results of the research should shed light on which services offered by rural hospitals are costly and which are not costly, what the optimal hospital size and occupancy rate are for the sample being scrutinized, and which organizational forms tend to display lower costs.

CHAPTER 2

TRADITIONAL COST ANALYSIS AND THE HOSPITAL INDUSTRY - ANALYSIS AND LITERATURE REVIEW

Chapter 2 addresses some of the problems encountered in a cost analysis hospital, and some of the techniques used to overcome these problems. The chapter is divided into four sections. Section I is a review of traditional cost analysis under the assumption of profit-maximization for a firm utilizing one or more inputs to provide a single output in accordance with a specified production function. Section II extends the theory of Section I to encompass particular characteristics of the hospital industry. Section III discusses some of the problems encountered when doing cost analysis in the hospital sector and Section IV is a brief literature review of methodologies employed to solve the problems of Section III.

Traditional Cost Analysis

Traditional cost analysis begins with a discussion of the nature of the firm's production function. This is logical because, as will be shown, it is the firm's production function and the prices that the firm pays for inputs that determine the firm's cost function.

Production is defined as the process in which inputs are combined and/or transformed to provide some quantity of output. The production function is nothing more than the relationship between the quantity of inputs used and the quantity of output that can be obtained as a result. In other words, it provides us with a description of the current state of technology. For the single-output, two-input firm the production function may be expressed as

(1) $Y = f(X_1, X_2)$

which often is expressed for convenience as

(2) $Y - f(X_1, X_2) = 0$

or more simply

(3) $g\ (Y, X_1, X_2) = 0$

For a firm such as a hospital that utilizes many different inputs to produce a variety of outputs the production function may be expressed as

(4) $g(Y_1, Y_2, \ldots Y_n; X_1, X_2, \ldots X_n) = 0$

which simply states that varying proportions of the various inputs can be used to produce varying proportions of the various outputs.

Of importance to traditional cost analysis is the assumption of profit-maximizing behavior on the part of firms.* Although many contemporary authors have cited cases based on sound evidence that this is not always the firm's objective, the assumption provides an analysis that is at worst a close approximation of firm behavior and at best

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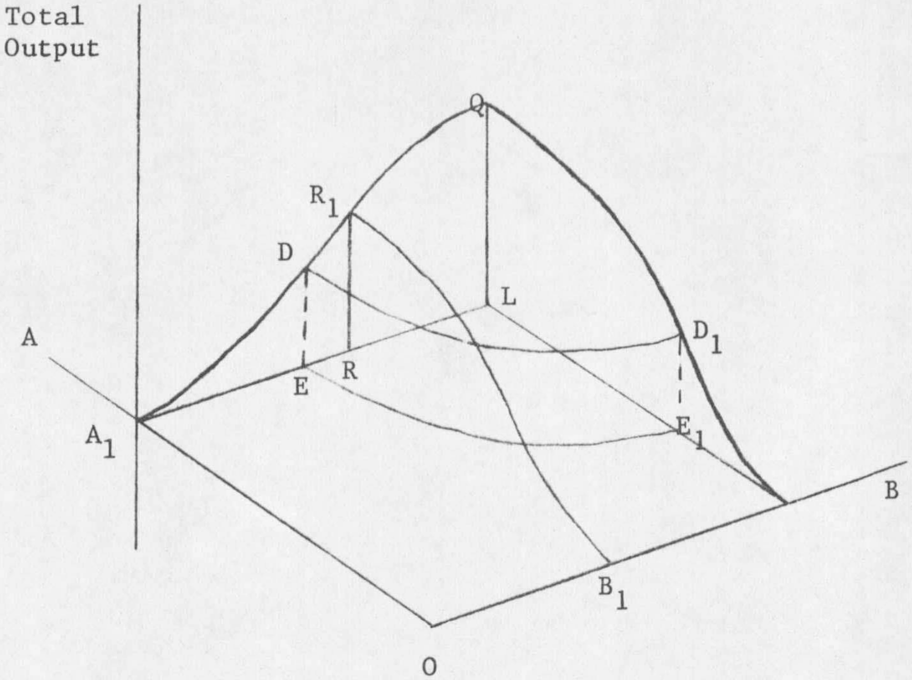
* Alternatively this may be stated as cost-minimizing behavior.

precisely the nature of a firm's operation. Although hospitals are not necessarily profit maximizing firms the following description of the production process is characteristic of hospitals as well.

The nature of production for the single-output, two-input firm is illustrated in Figure 2-1. Here total output, a function of inputs A and B, is determined by the vertical distance from the plane OA_1LB to the production surface. For example, if quantity A_1 of input A is combined with quantity B_1 of input B, the resulting output would be measured by the distance RR_1. Figure 2-1 also shows how output varies with changes in one of the inputs while holding the other input constant. For example, the line B_1R_1 shows how output changes while holding the quantity of input B constant at B_1, and varying the quantity of input A from zero to A_1 units. Here the first few units of the variable input result in increases in output at an increasing rate, but eventually output begins to increase at a decreasing rate. This is due to the Law of Diminishing Marginal Returns which states that as further increments of a variable input are added to the production process, other inputs held constant, eventually output will increase at a decreasing rate. Although it can not be deduced from any physical or biological laws, empirical observation generally supports the intuitive appeal of this law.

A line of constant elevation on the production surface, such as line DD_1, projected down to the base plane results in a convex shaped

Figure 2-1. The Production Surface.

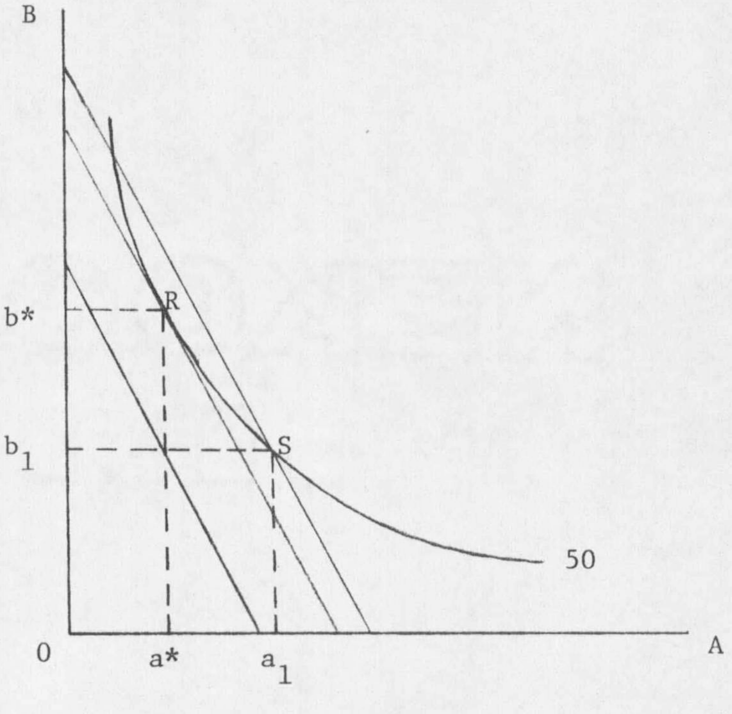


curve (called an isoquant) like the curve in Figure 2-2. Isoquants are two-dimensional representations of the various combinations of two inputs that provide a constant amount of output. Figure 2-2 illustrates how the entrepreneur can use either a* units of input A and b* units of input B, or a_1 units of input A and b_1 units of input B to provide an equal amount of output.

The profit maximizing firm is interested in the lowest cost means of producing a given level of output. This is determined with the aid of the downward sloping straight lines in Figure 2-2 which are called isocost lines. Isocost lines are lines showing all the possible combinations of inputs that could be utilized for a given level of cost. The slope of the lines is determined by the ratio of the prices of input A and input B. More precisely the slope is equal to $- P_A/P_B$. The lowest cost quantities of each input to be used in the production of a desired output level are determined by the point of tangency of the isoquant with the appropriate isocost line. This is point R in Figure 2-2. The least cost combination of A and B is a* and b*. Note that the same amount of output could be produced by using the quantities a_1 and b_1 of inputs A and B. This would be an inefficient process, however, because point S lies on a higher level isocost line than point R, and at point R the same amount of output can be produced at a lower cost.[†]

[†] Note that the dual to this problem is to determine the level of output that could be obtained given a specific level of cost. In this case the solution is to pick the isoquant that lies just tangent to the given isocost line.

Figure 2-2. Isocost lines and isoquant.



There is some indication that hospitals, to the extent that they are biased against producing lower quality products, may not provide services utilizing the least cost combination of inputs [26].

Short Run v. Long Run. It is important to distinguish between the short run and the long run when discussing cost functions. As the following sections will show the underlying reasons for the shapes that cost curves take are different in the short and the long run. This is important to understand because cost curves in the short and the long run take on much the same shape. Also, while the short run is of more immediate importance to the firm's managers and decision makers, the long run cost curves are important for public policy decision making agents.

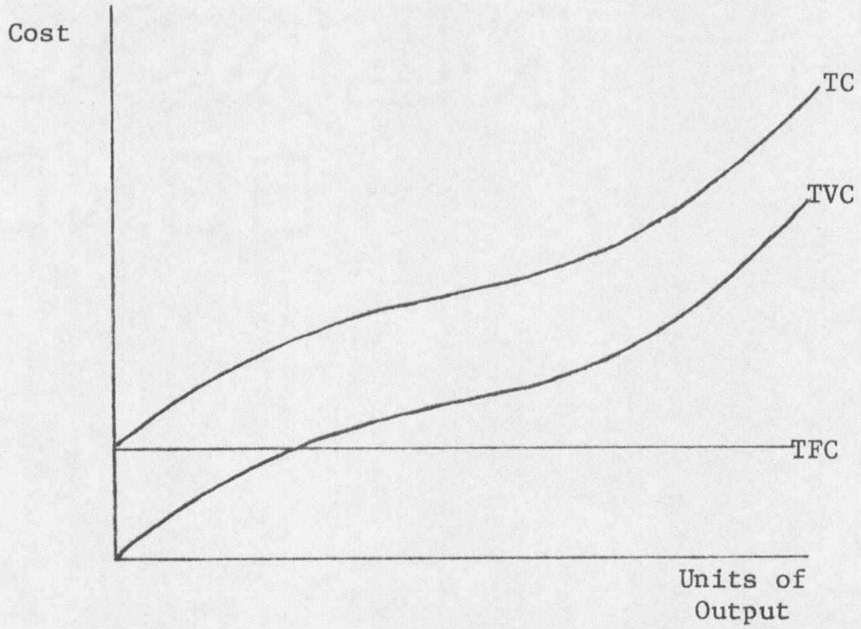
Generally speaking, economists define the short run to be a period of time such that some or all of the inputs to production remain fixed. This restriction usually pertains to plant size and machinery. The long run, on the other hand, is a period of time long enough that all inputs to production are variable.

The short run implies a fixed plant size. Hence, in the short run it is possible to distinguish between fixed and variable costs. Fixed costs are defined as those costs that do not vary with the amount of output. For example, even if no output is produced costs for rent, insurance, depreciation and managerial services are still incurred and are assumed to be constant in the short run. Variable costs are defined as costs that vary with changes in output. These include expenses for materials, electricity, labor, etc. Figure 2-3 shows three cost curves: the total fixed cost curve (TFC), the total variable cost curve (TVC) and the total cost curve (TC), which is the addition of fixed costs to variable cost at each level of output.

Two points concerning Figure 2-3 should be emphasized. First, the slope of the total cost curve is equal to the slope of the total variable cost curve at all units of output. This stems from the fact that the total cost curve is nothing more than the total variable cost curve plus a constant, the fixed cost. Second, it should be noted that both the TC and TVC curves rise initially at a decreasing rate and eventually at an increasing rate. This phenomenon is due to the Law of Diminishing Marginal Returns. Recall that the initial increments of variable inputs provide for the positive affect of increasing marginal productivity. If per unit input costs remain constant over the relevant range, this must result in decreasing marginal costs per unit of output. However, when the point is reached where additional units of input result in decreasing marginal productivity, the implication for costs is that they rise at an increasing rate.

For each of the total cost functions shown in Figure 2-3 there is a corresponding average cost function. The average cost functions are determined by dividing each value of the total cost functions by the number of units of output at that value. For example, average fixed

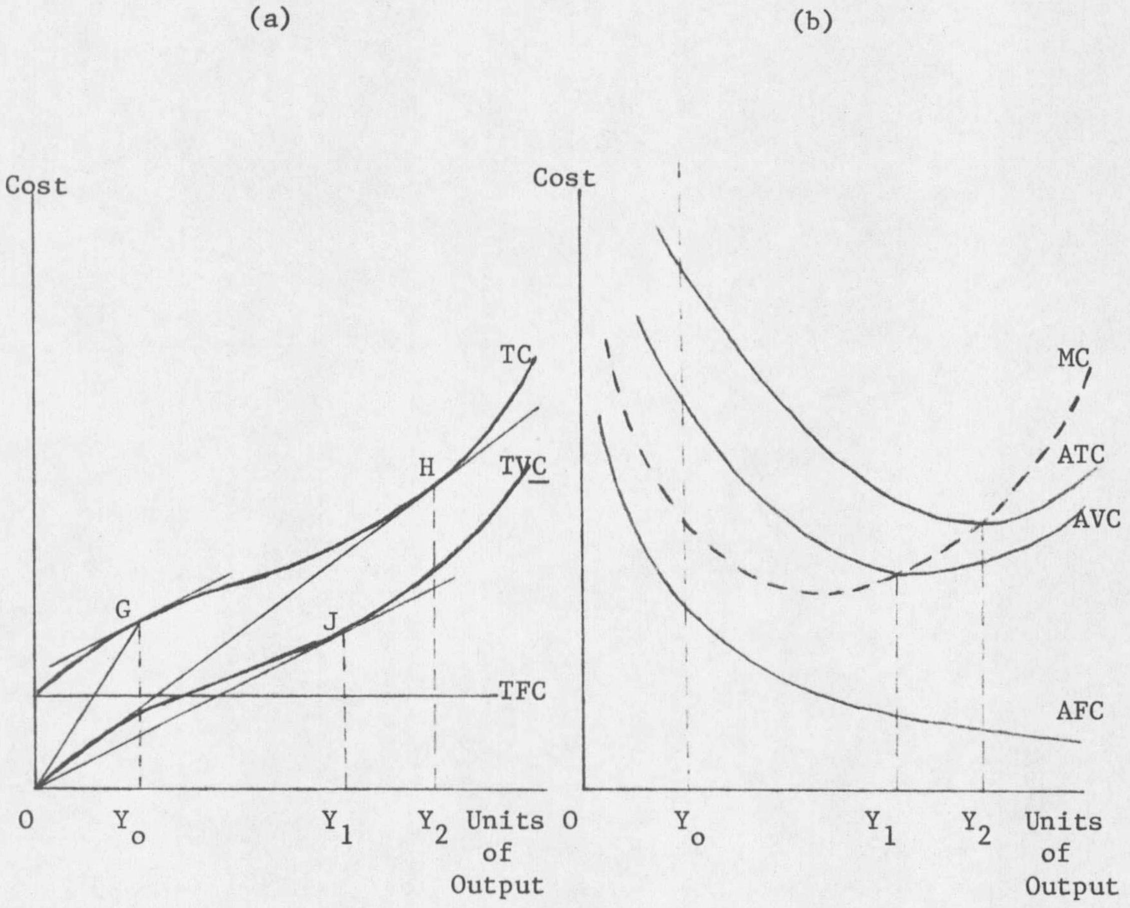
Figure 2-3. Total Cost Curves.



cost would be fixed cost divided by output level (Y), or AFC = $\frac{TFC}{(Y)}$, and average variable cost would be AVC = $\frac{TVC}{(Y)}$, etc. Graphically, average costs are indicated by the slope of a line from the origin to the curve in question. Figure 2-4(a) shows the total cost curves while Figure 2-4(b) shows the corresponding average cost curves. Since the TFC curve is constant throughout the relevant range the AFC curve continues to decline and asymptotically approaches the X-axis. The ATC and AVC curves decline at first, reach a minimum, and then begin to rise. This is in accordance with what is happening to the slopes of lines extending from the origin to all points on the TC and TVC curves as output increases.

The final curve to be considered in short run cost analysis is the marginal cost curve (MC) which is defined to be the change in cost occurring from a unit change in output. Graphically, marginal cost is measured as the slope of the line tangent to either the TC or the TVC curve at any given level of output. Two points should be recognized about the relationship between the AVC or the ATC curve and the MC curve. First, when either the AVC or the ATC curve is falling, the MC curve must lie below it. Conversely, whenever the ATC or the AVC is rising, the MC curve must lie above it. This is illustrated at point G in Figure 2-4(a). At point G, at output level Y_o, the value for the ATC curve is given by the slope of line OG and is seen to be falling. The value of the MC curve at point G is given by the slope of the line

Figure 2-4. Total cost and average cost curves.

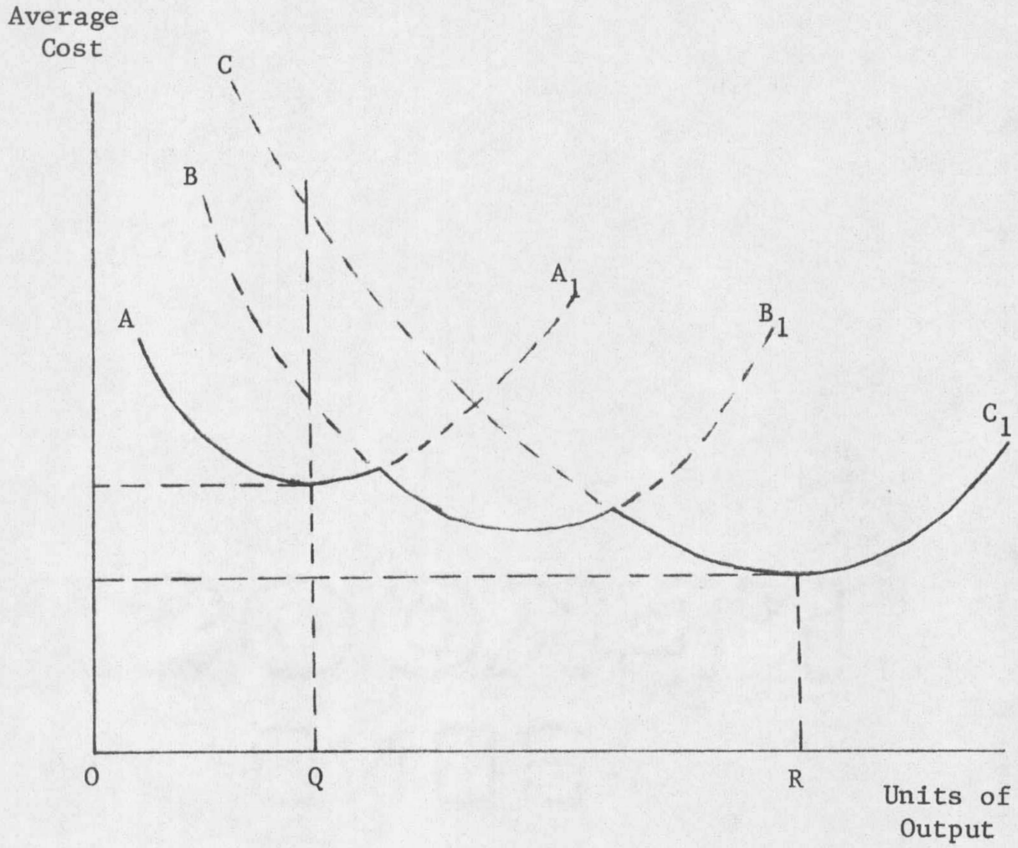


tangent to the TC curve at point G. It is obvious that the value for MC is smaller than that for ATC, and is also falling. Second, the MC curve coincides with the ATC curve and the AVC curve at the minimum points of these latter two curves. This is illustrated at points H and J where the rays from the origin, having fallen as far as they will, are also the lines of tangency to the curves at point H and J. Hence, the slope of the average cost lines equals the slope of the marginal cost lines and MC will equal AVC and ATC at output levels Y_1 and Y_2 respectively.

In the long run none of the inputs to production are fixed, including plant and equipment, and the level of output becomes primarily a function of management's perceived demand for output in the future. Consider a firm that has the option of renting three different sized plants. The short run average cost curves for each plant are presented in Figure 2-5. The choice of plant size will depend on the expected level of output the firm believes it will be able to sell. If it expects to sell Q units of output, then the plant having the short run average cost curve AA^1 should be rented because that plant produces quantity OQ of output at a lower cost per unit than either of the larger plants. If output is expected to be higher, such as the output level OR, then a larger size plant should be rented; in this case, the plant having short run average cost curve CC^1.

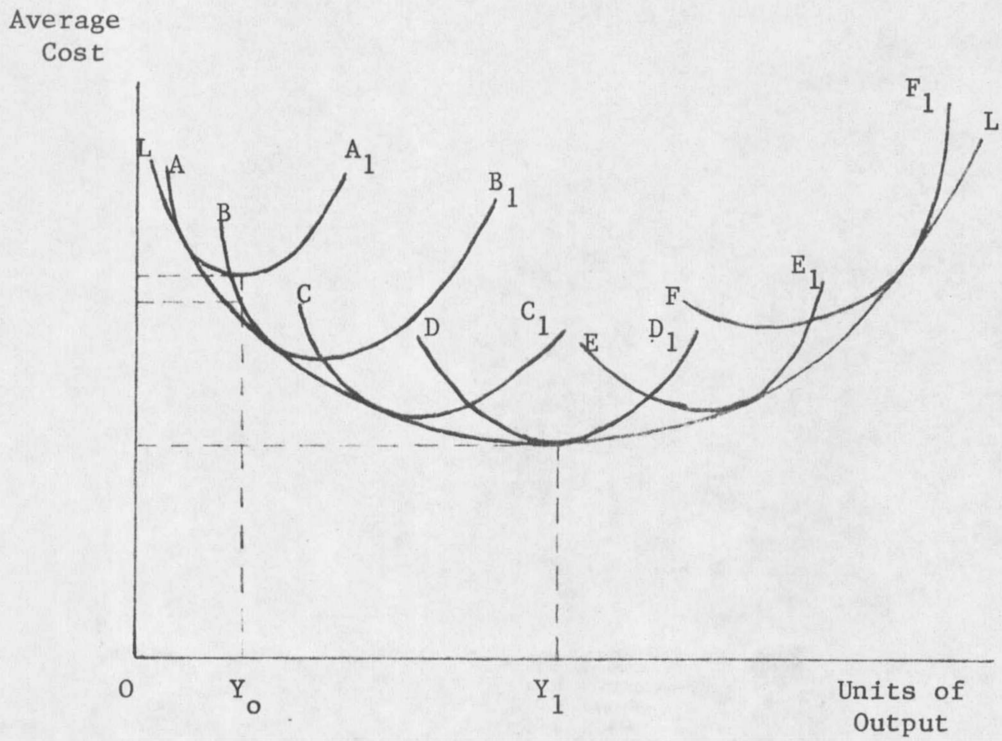
In the more general case, firms facing the future have the option of constructing any size plant they desire. This situation is

Figure 2-5. Short Run Average Cost Curves For Three Different Firm Sizes.



illustrated in Figure 2-6. There are virtually an infinite number of short run cost curves and the long run average cost curve becomes the smooth curve LL^1 that lies tangent to some point on all of the short run average cost curves. Curve LL^1 is referred to as the envelope of the short run average cost curves. Note that to the left of the minimum point on the long run average cost curve LL^1 the points of tangency are all on the downward sloping portion of the short run average cost curves. The explanation for this observation is made clear by examining what happens at output level Y_0. If the firm were to build plant AA^1, it would be able to produce output Y_0 at the minimum cost point of the short run average cost curve AA^1. This would be inefficient, however, because the same amount of output could be produced at a lower average cost per unit utilizing the plant size having average cost curve BB^1. Only at output level Y_1, where the low cost point of the long run average cost curve coincides with the low point on the short run average cost curve, is it efficient for the plant to be operating at the minimum of its short run average cost curve. To the left of Y_1 it is efficient for plants to operate at below minimum cost capacity and to the right of Y_1 it is efficient for plants to operate above minimum cost capacity. If the u-shaped long run average cost curve is characteristic of the hospital industry then we might expect smaller, rural hospitals to be operating at less than full utilization of capacity.

Figure 2-6. Envelope Of The Short Run Average Cost Curves.



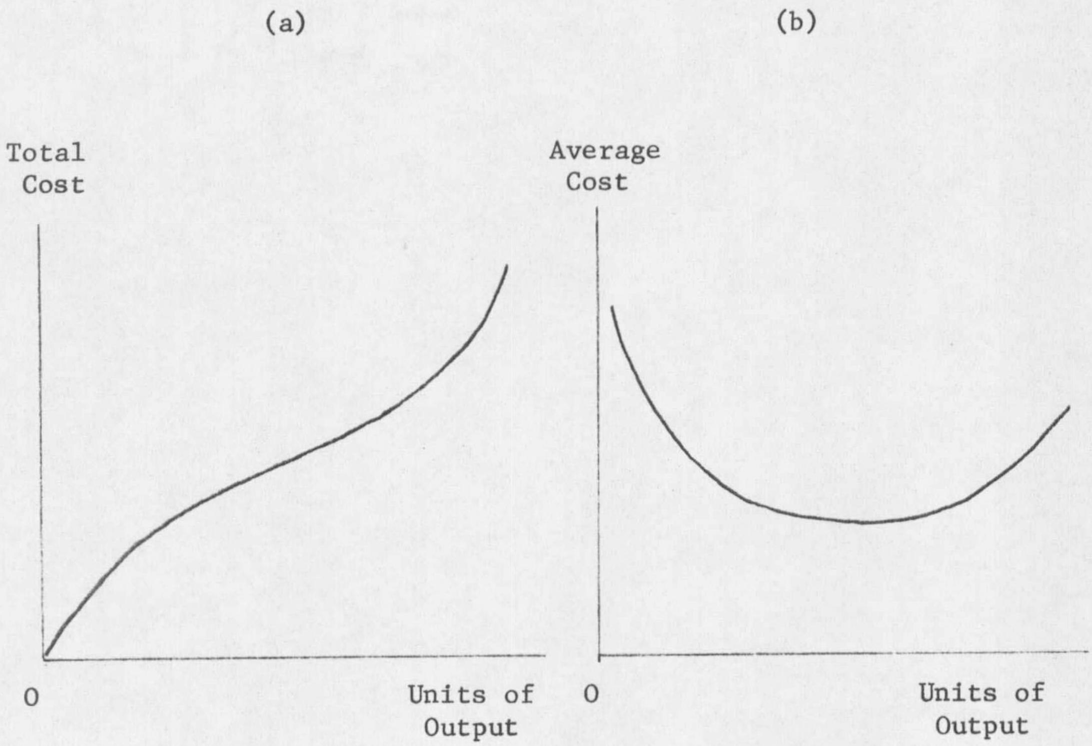
The long run total and average cost curves of Figure 2-7 are very similar in shape to the short run total and average cost curves. However, whereas the short run total and average cost curves derive their shapes as a consequence of the Law of Diminishing Marginal Returns, the long run total and average cost curves derive their shapes as a consequence of economies and diseconomies of scale.

Economies of scale are captured on the downward sloping portion of the long run average cost curve. "Economies of scale" means that as plant size grows per unit average cost falls. Diseconomies of scale occur along the upward sloping portion of the long run average cost curve and mean that as plant size grows per unit average costs rise. Indivisibility of inputs and specialization in larger plants are often cited as reasons for economies of scale, whereas the increasing complexity of managing a large firm is believed to be a primary cause of diseconomies of scale.

Traditional Analysis and the Hospital Sector

In the traditional neo-classical world of economics entrepreneurs are motivated to devote resources to the production of goods and services because of the opportunity for profit-maximization. Furthermore, it is assumed that consumers purchase goods and services on the basis of their "willingness to buy". This in turn assumes that the consumer is informed completely as to the nature of the product and what must be given up in order to acquire the product.

Figure 2-7. Long Run Total And Average Cost Curves.

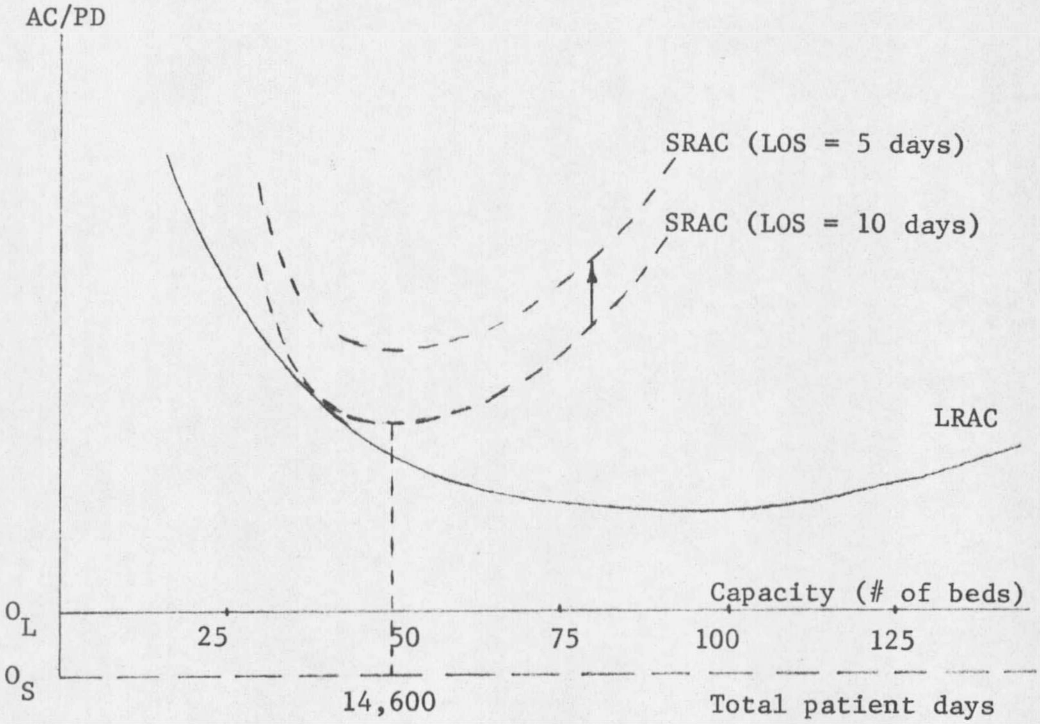


Contrary to these conditions, the hospital sector is characterized predominantly by non-profit institutions offering services that are frequently not understood by the consumer. Also, in many instances the demand for hospital services may not have originated with the patient but instead with the attending physician. And in most cases the individual receiving treatment is not fully aware of the cost of treatment because of existing insurance coverage methods of payment.

Generally it is agreed that the effect of these characteristics is to increase average costs per unit of output. Joseph Newhouse argues that hospital inefficiency is reinforced by a bias against producing lower quality products, barriers to entry by for-profit firms due in large part to the philanthropic aspect of hospital funding, and the removal of an effective budget constraint induced by third-party methods of payments [26].

One hypothesized relationship between the long run average cost (LRAC) curve and the short run average cost (SRAC) curves is depicted in Figure 2-8. In this analysis the LRAC curve represents the relationship between average cost per patient day and the capacity of the hospital. Capacity here refers to the extent to which an institution is capable of producing more units of output. Although it can be argued that capacity is a function of the size and training of the staff, the length of stay, the mix of cases treated and the number of available beds [27], the latter measure is adopted in this study in

Figure 2-8. The Hospital's Long Run And Short Run Average Cost Curves



Note: The axis labeled 0_L refers to the LRAC curve while the axis labeled 0_S refers to the SRAC curve. If the 80 percent occupancy rate proposed by the National Guidelines were the most efficient level of hospital operation the short run average cost curve would reach a minimum at 14,600 (50 x .80 x 365) total patient days for a fifty-bed hospital. This is the situation depicted in Figure 2-8.

order to facilitate comparison with past efforts. In Figure 2-8 the LRAC curve suggests significantly increasing returns to scale in smaller hospitals, falls to a region of relatively constant returns to scale and finally begins to rise in a region of decreasing returns to scale.

The SRAC curve for a hospital of given capacity (i.e., 50 beds) is drawn as the dashed curve in Figure 2-8. A hospital SRAC curve represents the relationship between average cost per patient day and the number of units of output produced (the unit of output in this instance being the patient day). The shape and location of the SRAC curve are a function of the intensity of utilization of the hospital's capacity. Intensity of utilization can be increased by increasing the occupancy rate or decreasing the mean length of stay for a given case mix while maintaining the same occupancy rate.

Increasing the occupancy while holding the mean length of stay constant increases the number of patient days produced and is represented as movement along the SRAC curve. The SRAC curve of Figure 2-8 indicates that as more patient days are produced the average cost per patient day of treatment falls to a minimum and then begins to rise. The curve may begin to rise in response to hiring of additional personnel or the payment of overtime wages to existing personnel when occupancy rates are very high.

Decreasing the mean length of stay per case while maintaining a constant rate of occupancy shifts the average cost curve upwards.

resulting in an increase in the average cost per patient day. Although there are no more or less total patient days produced, there is an increase in the average amount of resources used per patient day as a result of the higher intensity of utilization and this produces higher costs per day.

The objectives of this thesis include providing estimates of the minimum (least cost) points on the LRAC and SRAC curves as well as the effect of changing average length of stay on average cost. The next section considers several problems encountered when undertaking an analysis of this nature.

Some Problems Encountered in Hospital Cost Analysis

The difficulties in determining underlying cost functions for hospitals have resulted in a diversity of attempts to define cost functions and a lack of consensus in results. For example, economies of scale in the production of services would, on the surface, appear to be a reasonable assumption. However, examination of the literature reveals that not only is there a lack of consensus as to whether economies of scale exist, but there also is wide divergence of opinion in regards to the least cost hospital in terms of numbers of beds (Table 2-1). This lack of consensus concerning scale economies is aptly summed up by Sylvester Berki when he writes "...depending on the methodologies and definitions used, economies of scale exist, may exist, may

Table 2-1

The Existence of Scale Economies: Summary of Findings*

Investigator	Existence of Economies of Scale	Min. Long-run Ave. Cost Point (In terms of beds)
Cohen, 1967	Yes	150-350 depending on output definition
Cohen, 1967	Yes	540-790 depending on quality measure
P. Feldstein and Carr	Yes	190
Ro, 1968	Yes	900
M. Feldstein, 1968	Yes	300-900 depending on equation specification
Ingbar and Taylor, 1968	No	
Francisco, 1970	No	
Panel on Hospital Care, 1967	No	
Lave and Lave, 1970 [33]	No	

*Source: All but the last entry in this table are taken from a similar table in Berki, Sylvester, Hospital Economics, Lexington, Ma., D.C. Heath and Company, 1972, pg. 115.

not exist, or do not exist, but in any case, according to theory, they ought to exist" [28].

Economies of scale is not the only topic on which there is a divergence of opinion. "An empty bed is 75 percent as expensive as a full bed", for example, is often heard in the literature [29]. This implies that the additional cost of admitting the next patient is approximately one-fourth the cost of the patients already in the hospital. Corroborating this notion are the efforts of several investigators including M. Feldstein, who finds marginal costs per case to be about 20 percent of average costs [30] and P. Feldstein, who concludes that marginal costs are 21-27 percent of average costs [31]. However, S. Berki asserts that there is "...fairly general agreement among the investigators that marginal costs in the short run are a significantly large percentage of average costs" [32], and Lave and Lave, in a study of 75 Western Pennsylvania hospitals, conclude that marginal costs were somewhere between 40 and 65 percent of average cost [33].

There are a variety of factors that account for these different results. Central to the problem of cost analysis in the hospital sector is the inability of investigators to derive a production function for hospitals. Implicit in production function analysis is the ability to define the product in discrete physical terms, such as the number of automobiles or the number of tons of steel produced. When the nature of the product is characterized by these traits it is often a comparatively simple matter to determine the production function. All that is required is to establish the relationship between the quantity of inputs used and the quantity of output that is produced as a result. Generalized production functions serve to describe the nature of many firms. Two such production functions are the Cobb-Douglas production function, which allows for variable proportions of inputs, and the Leontiff production function, which specifies fixed proportions of inputs. Once a specific production function has been determined cost curves evolve as a matter of consequence.

The problem becomes much more complicated when dealing with a firm such as a hospital which employs several inputs to produce a variety of products such as inpatient care, education, research community services, and outpatient care. Although it is true that in rural hospitals the education and research aspects of hospital output seldom are important, one might view different case types as separate products.

Furthermore, there is little agreement as to the definition of a unit of output for the hospital. Perhaps some of the disparity in the conclusions of the various researchers is a result of variation in defining hospital output. Several approaches to defining output and their implications will be discussed in the next section.

An alternative approach to defining a production function from which cost curves can be derived is to determine the cost curves directly. Again there is a lack of consensus as to what constitutes a unit of output, but even if this problem could be surmounted, a detailed accounting of production costs would be required. Not all hospitals keep a detailed record of costs by department and in the hospitals that do allocate costs, a wide range of accounting techniques is used and the manner of allocation often is arbitrary. Consequently the data limitations associated with this method of cost analysis are severe.

Another problem that should be given consideration when making inter-hospital cost comparisons is the variation in cost from hospital to hospital which is a result of exogenously determined factors (that is, factors outside the control of the individual hospital). For instance, most researchers would agree that hospital wage rates in urban areas, and especially very large metropolitan areas, are higher than in rural areas. As a result, one would expect costs to be higher in urban hospitals. This cost differential is not a reflection of variation in operational efficiency from one hospital to another. Consequently, wage rate variations must be controlled for in any cost analysis where they are potentially severe.

It also is recognized that the quality of hospital care varies from hospital to hospital [34]. For example, it commonly is assumed that the quality of service in larger, urban, advanced teaching hospitals is superior to the quality of care in rural community hospitals. The reasons for this assumption are (1) larger teaching hospitals have access to the latest technology and innovative surgical procedures,

(2) they attract more highly trained physicians and nursing staff, and (3) they treat a larger number of complicated cases reducing the probability of error in the surgical process.

This quality differential could be reflected in costs in two ways. First, an increase in demand brought about by an increase in quality can be met only at increased total cost [35]. The second way in which quality may be reflected in costs is via the effects it has on case mix and case flow [36]. Case mix may be defined as the extent to which all or any of the International Classification of Diseases, Adopted (ICDA) categories of diagnoses are treated and case flow may be defined as the number of cases treated per bed year. If it is true that those hospitals designated as "quality" hospitals tend to specialize in the more severe and complex cases, then we could expect length of stay per case to increase, thereby reducing case flow. Although cost per case is increased substantially when case flow is reduced as a result of a specialized case mix [37], cost per patient day would tend to fall.

Increases in quality, therefore, usually imply increases in costs. But this is observed not only in hospitals but in most of the manufacturing industries also. A Mercedes costs more than a Chevrolet partially because of its superior quality. The difference lies in the consumer's ability to assess the value of the quality differential. In manufacturing automobiles an increase in quality, with no change in technology, results in increased cost but the value of the quality change can be closely approximated by comparing the accounting costs before and after the quality change. There is currently no precise way to do this in the hospital sector of the economy.

These, then, are a few of the major problems confronting the hospital cost analyst. The list is by no means exhaustive. The next section examines some of the methodology employed in addressing these problems.

A Review of Methodology

The most commonly used measure of output in hospital cost analysis is the patient day. Just as common among researchers is the realization that the patient day is not an accurate measure of output for comparison of hospital costs. This is because hospitals do not produce a homogeneous product. As the preceeding section pointed out, not only do large, urban, teaching hospitals tend to produce a higher proportion of complex cases per patient day, but one could argue that these hospitals also tend to provide treatment of higher quality than their smaller, rural counterparts. Several approaches have been utilized in attempts to account for product heterogeneity. Three methods will be discussed here.

Saathoff and Kurtz (1962) first recognized that the patient day is an inadquate measure of output [38]. Arguing that the use of patient days fails to take into consideration the extent to which the various services offered by hospitals are utilized, they constructed the following measure for output:

S = (adult, pediatric and newborn days)

+2 (surgical plus obstetrical admissions)

+.3 (X-ray diagnostic procedures)

+.1 (lab tests and tissue exams)

+.2 (outpatient visits).

The weights were based on time and motion studies performed on the various services. Although it appears to be a crude approximation of output in that the categories of factors contributing to total output are themselves susceptible to further delineation and the weights contain a considerable degree of subjective evaluation, the Saathoff-Kurtz scheme was a step in the right direction. It underlined the deficiencies involved in considering patient days as an output measure, and opened the door for further investigation into the definition of output.

Harold Cohen (1965) also recognized the problems involved in using "patient days" to measure output [39], and pointed out that use of this variable as an output measure biases against larger hospitals since the average patient day there uses more services. Data from 23 member hospitals of the United Hospital Fund of New York were used to derive measures of cost for 13 services. The thirteen services then were weighted according to their costs with an "adult and pediatric patient day" receiving a weight of one. An index of output was then constructed as: $S^k = \Sigma W_i Q_i^k$, where W_i is the weight of the service and Q_i^k is the quantity of the i^{th} service in hospital k. Using this measure of output, Cohen regressed costs on output and discovered an approximately U-shaped average cost curve with a low point around 290-295 beds for the hospitals within New York City. Martin Feldstein adopted this same definition of output in doing hospital cost analysis [40].

Once the notion of product heterogeneity between hospitals is accepted then it must be taken into account either by directly modifying the output measure, as was done by Saathoff and Kurtz, or by controlling for differences in characteristics peculiar to different hospitals. Berry (1965) suggested that hospitals providing identical service/facility mixes could be considered as producing a homogeneous product [41]. He tested forty different groups of hospitals, of which no single group contains less than ten hospitals, and discovered economies of scale in thirty-six of the forty groups. In twenty-six of the groups the economies of scale were significant at the .84 level.

These results should be considered in the light of two compli-cating circumstances. First, as Berki points out [42], the AHA data used in Berry's study merely report the presence or the absence of a service or facility and say nothing of the size, staffing, newness of equipment or the extent to which the service/facility is utilized. Second, if hospitals that have identical service/facility mixes do in fact produce a homogeneous product, then one would expect these hospitals to have comparable case mixes. However, in an article pub-lished in 1971 in which this hypothesis is tested, Lave and Lave conclude that "...institutional characteristics such as size, teaching status, and number of advanced services...explain only about 25 per-cent to 45 percent of the variation in the case mix measures con-structed..." [43].

A third technique for hospital cost analysis, utilized by M. Feldstein, Lee and Wallace, et.al., is to select a group of indepen-dent variables to be used in a multiple regression analysis explaining the variation in costs from hospital to hospital.

M. Feldstein showed that there is substantial inter-hospital variation in case mix [44]. Implicit in this observation is the hypothesis that hospitals treating a higher proportion of high cost cases naturally should have higher costs. He distinguished 14 cost categories (medical, nursing, drugs, total, etc.) that make up the costs for nine different specialty categories (general medicine, pediatrics, general surgery, other, etc.). The 14 categories of cost then were regressed on case mix and the result was that 27.5 percent of the variation in ward costs per case was attributable to case mix variation [45]. He concluded that researchers in their "...attempts to compare hospitals' costs for administrative or research purposes or to establish relationships between cost and other characteristics...should, therefore, generally take case mix into account" [46].

Lee and Wallace also examined the relationship between average cost per day and case mix [47]. Their analysis differed from that of Feldstein since they defined case mix according to two different schemes: in the first study case mix was based on the "duration and extent of disability", in which there are five groups - long term severe, long term not severe, short term severe and short term not severe, and others - and in the second study case mix was based on the International Classification of Diseases, Adopted (ICDA), of which they used 16 groups. For each scheme a number of equations of the following form were then estimated:

$$C = a_o + \sum_{i=1}^{n-1} a_i P_i + \mu$$

where C is average cost per day, P_i is the proportion of cases that are of the i^{th} type, and μ is a residual. For the year 1966 the "duration and extent of disability" scheme explained 29.5 percent of the variation in cost from hospital to hospital while the ICDA scheme explained 52.2 percent of the inter-hospital cost variation [48]. The Lee and Wallace results indicate that the specification of the classification scheme is important in determining the power of the case mix variable. They conclude that "...the case mix variable developed on the basis of ICDA has greater explanatory power than the other scheme possibly because the former approximates more closely the underlying production functions."

As was mentioned earlier, the variation in wages can create problems in hospital cost analysis, especially when comparing costs of urban and rural hospitals. This problem was addressed in a systematic manner by Harold Cohen [49]. From the response of a questionnaire sent to all of the accredited short-term general hospitals in a six-state northeastern region, he determined that not only were there wage differentials between the four major regions of the United States (this information was obtained from the U.S. Bureau of Labor Statistics), but that there were considerable wage differentials in the northeast region and, on a smaller scale, between "upstate" and "downstate" New York. To eliminate the effect of wage differentials Cohen developed the following formula [50]:

$$A^k = C^k + [(S_i - S_i^k)(P_i E_k 52\ H_i)]$$

where

A^k = total adjusted cost for hospital K

C^k = total costs reported by hospital K

S_i = median starting salary for i^{th} occupation among hospitals in the sample

S_i^k = starting salary for i^{th} occupation reported by hospital K

P_i = proportion of employees in i^{th} occupation

E_k = total employment in hospital K

52 H_i = yearly hours per employee in i^{th} occupation.

The effect of the formula is to raise the total cost of non-urban hospitals and lower the costs of urban hospitals such that all wage differentials are eliminated.

Unfortunately, the problem of quality differentials has received little attention in the literature on hospital cost analysis. Part of the problem is that measuring quality is a difficult task. One might say that Hospital A is of higher quality than Hospital B, but there is no measuring stick by which one can say that Hospital A has 1.3 times as much quality as Hospital B. As Martin Feldstein has acknowledged, "Measuring the quality of medical care remains an unsolved problem. If useful quality indices are ever developed, a new dimension could be added to the assessment of hospital costs" [51].

Attempts to control for quality that have been made usually focus on the accreditation and affiliation characteristics of hospitals. This was the approach taken by Harold Cohen (1970) who divided hospitals into three quality groups: 1) hospitals not accredited by the Joint Commision on Accreditation, 2) hospitals accredited by the Joint Commission but not affiliated with a medical school, and 3) hospitals affiliated with an approved medical school [52]. Cohen examines quality/cost relationships in two steps. First a dummy variable (1, if the hospital was affiliated with a medical school; 0 if not) was used to test whether variations in cost might be explained by quality differences. In the second step the output measure developed in a previous paper, $S^k = \sum_i W_i Q_i^k$, was modified by adding a dummy variable to accomodate three sets of weights, $S_d^k = d \sum W_i Q_i^k$. The dummy variable, d, was set equal to one if the K^{th} hospital was unaffiliated, and to 1.1, 1.2, or 1.3 if affiliated. (Here it was assumed that the average output of an affiliated hospital was composed of 10, 20, or 30 percent more care than that of an unaffiliated hospital.) Using this procedure, four cost curves were derived. In all instances the quality variable was correlated positively with cost and was a significant explainor of variations in cost. As Cohen freely admitted, the results are merely suggestive: "In the absence of any definitive set of weights suitable for comparing output in teaching with that in non-teaching hospitals, three sets of weights were chosen to give the reader a choice and to evaluate the effects of these weights on the cost schedule [53]." In summary, the quality differential problem clearly is important, but to date no convincing method of controlling for quality variation has been developed.

CHAPTER 3

STATISTICAL COST FUNCTIONS, MODELING AND DATA DESCRIPTION

Chapter 3 is divided into three sections. The first section presents a discussion of some of the theoretical implications of using ordinary least-squares regression analysis and the underlying assumptions inherent in the technique. Hypotheses about the expected effect of the independent variables on average cost per patient day also are presented. Section two describes the model and methodology used in the analysis, while section three provides a description of the data and some preliminary conclusions reached from examination of the descriptive statistics.

Statistical Cost Functions

When well-defined production functions do not exist cost functions must be determined directly. One method of obtaining cost functions directly is by using ordinary least-squares multiple regression. If costs are believed to be a function of several observable variables, one can write

$$Y = f(X_1, X_2, \ldots, X_n),$$

where Y represents either total or average costs and $X_1, X_2, \ldots, X_n$ represent those variables that are perceived (a priori) to be significant explainors of the variation in cost from observation to observation. More specifically, regression techniques provide us with an equation of the form

$$Y_i = a_0 + a_1X_{i1} + a_2X_{i2} + \ldots + a_nX_{in} + e_i$$

where a_0 is a constant term; $a_1, a_2, \ldots, a_n$ represent the proportional change in Y for a unit change in the corresponding X; and e_i is an error term that picks up random disturbances not otherwise specified by the equation. The following assumptions are made concerning the error term [54]: 1) e_i is normally distributed with mean zero, 2) every e_i has the same unknown variance, σ^2, (homoskedasticity) and 3) the disturbances are nonautoregressive, that is, the e_i's are independently distributed.

Multiple regression analysis can be used to provide estimates of long run and short run total and average cost functions. There are two approaches to estimating long run cost functions: time-series analysis and cross-section analysis [55]. The goal of both approaches is to estimate the relationship between cost and output as the size of the firm varies over the relevant range. The time-series approach requires observations on a firm over a period of time during which the scale of plant is changing. The wider the range of plant sizes the more the analysis is likely to provide an accurate picture of the long run cost function. A single cost function then is estimated for the firm using cost as the dependent variable and output as the explanatory variable. Examination of the various cost function estimates that result as this procedure is applied to different firms provides the investigator with an idea of the nature of the long run cost function for hospitals.

Alternatively, in cross-section analysis cost and size of plant data are gathered from several firms at a point in time (i.e., for a single year) and a single equation representative of all the firms is estimated, once again using cost as the dependent variable and output or size as the independent variable. As before, the variation in plant scale should be large enough to provide for fitting a curve over the range of scale under consideration.

In the present analysis the small number of annual observations on each firm (seven) severely restricts the use of time-series analysis, hence cross-section analysis will be used to estimate the long run effects of size on cost. This will be accomplished by using both a size and a size-squared variable in the regression equation where size (capacity) is measured by the number of available beds in the hospital [56]. Traditionally one would expect to find a negative coefficient on the size variable, indicating decreasing costs as a function of size; and a positive coefficient on the size-squared variable, indicating a section of decreasing returns to scale after some minimum cost point is reached. However, because the observations are restricted to small, rural hospitals, the range under consideration may indicate that cost is a monotonically decreasing function of size (i.e., little or no significance on the coefficient of the size-squared variable). Alternatively, the coefficient may be significant but not large enough to turn the curve up in the relevant range.

This thesis will utilize estimates of average rather than total cost functions. Measuring output as the number of patient days while measuring capacity by the number of available beds reduces the "regression fallacy" problem and any simultaneous equations problem that might arise when output is used as a measure of scale [57].

Because of the historically low rates of occupancy in rural hospitals (the mean for the hospitals analyzed in this study is 50.7 percent with a standard deviation of 17.0 percent) it is important for administrators, policy makers, planners and physicians to understand the implications of increasing the rate of occupancy. Including this variable in the specification of the cost function provides us with an indication of the effect on average cost per patient day for changes in the occupancy rate. It also permits the calculation of the marginal cost per patient day of admitting one more patient. A comparison of marginal and average cost will give some indication of the extent to which average costs can be reduced by increasing the occupancy rate [58]. Much of the reason for declining average costs as a consequence of increasing occupancy rates has been attributed to the fact that hospitals tend to staff for peak loads and this fixed component of costs becomes dispersed over a larger number of patients (i.e., patient days), thereby reducing the average cost per patient day [59]. Using an occupancy and an occupancy-squared variable allows one to derive the short run average cost curve for hospitals. It is expected that the coefficient on the occupancy variable will be positive while the coefficient on the occupancy-squared term will be negative yielding a u-shaped curve.

Occupancy rates are only one component of the extent to which hospitals utilize available capacity. The other component, sometimes called intensity of utilization, is determined by the average length of stay of patients in the hospital. Longer lengths of stay tend to reduce the average cost per patient day but increase the average cost per case. This is because the costs of the more expensive days of admission, medical treatment and discharge are spread more thinly over longer stays thereby reducing average cost per patient day. It is therefore reasonable to expect a negative coefficient on this variable indicating decreasing costs per patient day with increasing lengths of stay [60]. Although a substantial amount of length of stay variation can be explained by the mix of cases treated in a hospital [61], health officials and administrators have indicated that length of stay is also dependent on the attitudes and personalities of the attending physicians. Therefore, this variable will be utilized in regressions in which case mix is and is not explicitly accounted for [62].

Cross-section regressions will be estimated for each year of the study to determine how the cost function is changing from year to year and also to examine the changing relationship of marginal to average cost. In addition, a pooled time-series, cross-section analysis will be conducted to obtain estimates of the cost function of the group of hospitals for the entire period under consideration. In this latter analysis a time variable is included to gain some insight into how costs have changed from year to year as a result of general increases in the prices of other inputs to production that come about as a result of inflation in the economy as a whole. One of the forms to be tested in estimating the cost function is a natural log specification. The coefficients of the year variables in the log specification estimate the annual rate of inflation of hospital services for this sample of hospitals. The size and size-squared variables determine the shape of the long run average cost curve while the occupancy and occupancy-squared variables determine the shape of the short run average cost curve. The remaining variables are "neutral" shifters of the cost curves in that they only move the curves up or down without altering the shape of the curve.

In rural communities it is not uncommon to find institutions providing hospital and nursing home care within the same facility. Because the study is concerned with the costs of acute, short-term services, hospitals reporting data for a facility in which both short-term and long-term services exist tend to confound the results. Not only are the methods of cost allocation and reimbursement different for each type of service but, as was indicated above, a longer length of stay tends to reduce costs per patient day. Including long-term beds in the analysis therefore tends to bias average cost estimates downward. To control for this effect a variable expressing the number of long-term beds as a percentage of total beds is entered in the specification of the cost function. The coefficient on this variable is anticipated to be negative indicating that the greater the percentage of long-term beds at an institution, the lower the average cost per patient day of treatment.

Data detailing the mix of personnel from institution to institution and wage rates for the different categories of workers were not available at the time of this research. To control for wage rate variation a rough proxy, total payroll divided by number of full-time employees, is used instead. Again, it is hoped that the homogeneous nature of this particular sample of hospitals will to some extent reduce this problem.

Although quality of service is not considered in great detail in this study, some control for quality is taken into account by including a dummy variable (a variable indicating the presence or absence of a particular hospital characteristic) for accreditation. It is anticipated that the coefficient on this variable is positive, indicating higher average cost per patient day for accredited hospitals. Some analysis also will be done to determine if variation in average cost can be explained by differences in the form of ownership, or control. Specifically, it is expected that for-profit institutions, represented again by a dummy variable, will have a negative coefficient indicating lower average costs in these institutions.

Case mix has been shown to be a substantial explainor of hospital costs [63]. Unfortunately case mix data are not available for this particular group of hospitals. Instead the variables "births per 1000 population" and "percent of the population over 65" are added to the specification as a surrogate. Because births usually constitute a very short length of stay and intensive use of resources while the aged may require a long recuperative period we might expect to find a positive and a negative coefficient on these variables respectively. However, because diseases of the aged tend to require intensive use of medical services one might conceivably hypothesize a positive coefficient on the latter variable as well.

Finally, in order to provide health planners with some indication of how average costs change with the type of institution, the sample of hospitals will be broken down into specific categories on the basis of service/facility configurations and the aforementioned variables will again be utilized in a cost analysis of each service/facility group. Comparison of the average and marginal costs from group to group will then give decision makers an idea of the differences in cost from type of institution to type of institution when formulating plans for a health care system.

Model and Methodology

The methodology used in this analysis is based on techniques presented by Lave and Lave [64] and Ralph Berry [65], however no time-series analysis is undertaken due to the small number of observations across time (seven). To obtain estimates of the long and short run average cost curves the data were pooled and used in a time-series, cross-section analysis. Linear, quadratic and log specifications are estimated in order to determine which form most closely fits the underlying production function. The three basic cost function specifications are:

(1) $^{AC}/_{PD} = a_0 + a_1 t + a_2 S + a_3 u + \varepsilon_i$ (linear specification)

(2) $^{AC}/_{PD} = a_0 + a_1 t + a_2 S + a_3 S^2 + a_4 u + a_5 u^2 + \varepsilon_i$

(quadratic specification)

(3) $\ln {^{AC}/_{PD}} = a_0 + a_1 t_1 + a_2 t_2 + a_3 t_3 + a_4 t_4 + a_5 t_5 + a_6 t_6$

$a_7 \ln S + a_8 \ln u + \varepsilon_i$ (log specification)

where t is the time variable, S is the size variable and u is the variable for occupancy rates (utilization). The time variable in the log specification is broken down into "dummy" variables for each year of the period (the first year is included in the constant intercept term, a_0) to estimate an annual inflation rate.

Theory suggests that the true cost functions in the hospital sector are a function of more than just time, size and utilization. The other variables hypothesized as being pertinent to the cost function specification in this analysis were described in the previous section.

The full-model specification incorporates all of the explanatory variables discussed in the preceeding section. The full quadratic and log specifications are as follows:

$$(4) \quad {}^{AC}/_{PD} = a_0 + a_1 t + a_2 S + a_3 S^2 + a_4 u + a_5 u^2 + a_6 LOS + a_7 A + a_8 AVESAL + a_9 \, {}^{LT}/_{TB} + a_{10} PP065 + a_{11} BPTHOUS + \sum_{i=12}^{29} a_i X_i + \varepsilon_i$$

$$(5) \quad \ln {}^{AC}/_{PD} = a_0 + a_1 t_1 + a_2 t_2 + a_3 t_3 + a_4 t_4 + a_5 t_5 + a_6 t_6 + a_7 \ln S + a_8 \ln u + a_9 \ln LOS + a_{10} A + a_{11} \ln AVESAL + a_{12} \ln {}^{LT}/_{TB} + a_{13} \ln PP065 + a_{14} \ln BPTHOUS + \sum_{i=15}^{32} a_i X_i + \varepsilon_i$$

where t, S, and u are as before, LOS is length of stay, A is accreditation, AVESAL is average salary, LT/TB is the ratio of long-term beds to total beds, PP065 is the percent of the population over age 65, BPTHOUS is the number of births per 1000 population and $\sum_i a_i X_i$ is the service/facility vector.

The Data

Sources. Nearly all of the data used in this analysis were taken from the American Hospital Association (AHA) Guide to the Health Care Field [66]. The information is voluntarily supplied by the hospitals on standard forms provided by the AHA. The data include professional affiliation and accreditation, form of ownership, medicare certification, a listing of the services and/or facilities offered, number of beds, average census, number of admissions, total operating expense, total payroll expense and number of employees. This information is used to determine average salaries, occupancy rates, average length of stay and average cost per patient day. Data were gathered for the years 1971-1977.

Through discussions with hospital administrators it was discovered that there was not strict uniformity in the reporting of total beds and total operating expenses regarding the number of acute and long term care beds at an institution. Some institutions, while reporting total operating expenses for both types of beds, were reporting only the number of acute beds. Therefore information pertaining to these variables was obtained through phone calls to each hospital in the sample.

Data for the variables "percent of the population over age 65" and "births per 1000 population" were obtained on a county by county basis from the County-City Data Book [67]. This information was available only for the years 1970 and 1975. Estimates of values for other years were obtained through straight line interpolation.

The Sample and "Rurality" Criteria. The sample included hospitals from each of five Rocky Mountain states - Montana, Idaho, Wyoming, Utah and Nevada (Table 3-1).

The predominantly unique aspect of this research is that the analysis is directed exclusively at rural hospitals. Since there are no established criteria concerning what constitutes a "rural" hospital, the inclusion of specific hospitals in the sample was somewhat arbitrary. Generally speaking, a hospital qualified as being rural if it was located in a city whose population was less than 12,540 and in a county whose population per square mile was less than or equal to 16. There were, however, some exceptions to these general rules. In these borderline cases a map of the area was consulted. For example, if a hospital was located in a city having a population of around 10,000, but was in a county so small that the population per square mile was inordinately high, the hospital was included in the sample if population in surrounding counties appeared to be relatively sparse.

Hospital Size. The sample of hospitals selected on the basis of these rurality criteria has a mean size of 41 beds (Table 3-2). The

TABLE 3-1

CASES BY STATE AND YEAR

	Montana	Idaho	Wyoming	Utah	Nevada	Total
1971	40	32	20	14	8	114
1972	42†	32	20	14	8	116
1973	42	32	20	14	8	116
1974	42	32	20	15	8	117
1975	42	32	20	15	8	117
1976	42	32	20	15	8	117
1977	41	32	20	15	8	116
	291	224	140	102	56	813

† The number of hospitals in Montana and Utah changed from year to year due to hospital construction or closure.

TABLE 3-2

FREQUENCY DISTRIBUTION OF HOSPITALS BY SIZE
(For the year 1974)

Size (in beds)	Absolute Frequency	Cumulative Frequency	
0-9	1	1	0.01
10-19	14	15	0.13
20-29	23	38	0.32
30-39	29	67	0.57
40-49	18	85	0.73
50-59	13	98	0.84
60-69	4	102	0.87
70-79	7	109	0.93
80-89	4	113	0.97
90-99	2	115	0.98
100-109	1	116	0.99
110-120	1	117	1.00

distribution of size is unimodal and positively skewed. Hospitals selected on the basis of the rurality criteria alone included one observation of a 148 bed hospital. This hospital, considered an extreme observation, was excluded from the analysis.

Form of Ownership. Table 3-3 shows the percentage of hospitals in the sample classified according to form of ownership. The categories "county" and "other" together account for 76 percent of all hospitals in the sample. "Other" hospitals include community hospitals, cooperative hospitals and hospitals operated by fraternal societies. The table also shows that the sample is almost evenly divided between public and private ownership (53 percent public), and almost entirely made up of not-for-profit institutions. It is interesting to note that the smallest category, "city" hospitals, constitutes only 1.5 percent of the sample. These hospitals are generally small facilities located in resort areas.

Salaries and Personnel. The mean salary (total payroll divided by number of employees) by state and year and the average number of employees per hospital in each year are given in Table 3-4. With the exception of Nevada, salaries are fairly uniform across states with the mean salary over the period of approximately $6,000. Also, with the exception of Idaho, there appears to be no general trend indicating that salaries have been increasing over this period of time; in fact, because the figures are not reported in constant dollars, it appears

TABLE 3-3

FORM OF OWNERSHIP

	% of Sample	Public	Not-for-Profit
County	.404		
City	.015	.526	
City-County	.019		.976
Hospital District or Authority	.088		
Church Operated	.093		
Other†	.356		
Corporation	.024		

† Includes fraternal organization sponsorship, etc.

TABLE 3-4

MEAN SALARY BY STATE AND YEAR($)
AND AVERAGE NUMBER OF EMPLOYEES PER HOSPITAL BY YEAR

	Idaho	Montana	Nevada	Utah	Wyoming	Employees
1971	5,894	5,851	7,799	5,685	5,988	58
1972	5,971	6,079	7,086	5,319	5,747	61
1973	6,157	6,048	7,423	6,863	6,760	60
1974	6,198	6,112	7,386	6,731	5,760	59
1975	6,075	6,050	6,792	6,227	6,765	66
1976	6,292	5,480	7,096	6,491	6,382	67
1977	6,534	5,661	7,769	6,340	6,008	69
Average over the Period	6,167	5,898	7,342	6,209	6,184	63

that real salaries may be falling. Finally even though salaries don't appear to be increasing over time, the average number of employees utilized by these hospitals does appear to be increasing. This indicates that hospitals either are maintaining approximately the same mix of personnel and not providing increases in the wage rate, or are allowing increases in the wage rate but countering these increases by shifting the mix of staff towards more employees in lower wage specialties. More research is needed before this issue can be settled.

Services/Facilities. Table 3-5 contains a list of services and/or facilities offered by hospitals in the sample. The category "other services" includes dental services, podiatric services, speech pathology, patient representative services, alcoholism/chemical dependency inpatient and/or outpatient services, TB and other respiratory diseases unit, self care unit, rehabilitation services and volunteer department. "Other medical services" includes open-heart surgery facilities, organ bank, hemodialysis (inpatient and/or outpatient) and burn care unit. In the regression analysis the occurrence or nonoccurrence of a particular service or facility was indicated by the value of a 0-1 binary variable, with the exception of the "other services" and "other medical services" categories which were given a value equal to the number of these kinds of services found in the hospital.

TABLE 3-5

PERCENT OF HOSPITALS OFFERING SERVICE

	1971	1972	1973	1974	1975	1976	1977	Ave.	Trend
Postoperative Recovery	35	35	41	47	50	50	50	44	↑
Intensive Cardiac Care	52	28	22	27	24	28	30	30	↓
Intensive Care	24	39	42	43	50	58	62	45	↑
Pharmacy	64	63	66	76	77	79	79	72	↑
Radiological Services	11	8	11	16	16	19	20	14	↑
Histopathology Lab	2	7	6	10	10	10	15	9	↑
Blood Bank	38	34	35	40	49	50	47	42	↑
Inhalation Therapy	27	27	39	50	45	50	55	42	↑
Premature Nursery	20	22	17	15	15	14	11	16	↓
Physical Therapy	33	35	40	47	53	57	59	46	↑
Psychiatric Services	9	10	8	12	12	13	16	11	↑
Outpatient Services	17	7	12	16	12	15	14	13	–
Emergency Dept.	78	80	76	83	89	85	88	83	↑
Social Services	5	5	10	14	14	15	15	11	↑
Volunteers	51	55	61	65	69	71	71	63	↑
Electroencephalography	2	1	2	8	11	15	13	7	↑
Other Services	–	18	17	22	33	44	44	25	↑
Other Medical Services	2	1	2	1	1	1	3	1.5	–

The trend column indicates the relatively increasing, decreasing or stable popularity of a particular service or facility. A general trend towards increased number of services offered by sample hospitals is indicated in that fourteen of the eighteen services have grown in popularity, two have remained fairly stable, and two have fallen in popularity. The popularity of the latter two servies (intensive cardiac care, premature nursery) may have fallen in recent years due to a trend towards concentrating care for these case types in regionalized centers.

Annual Means of Selected Variables. Table 3-6 presents the annual means of a set of variables important in explaining the changing nature of this sample of hospitals. Perhaps the most striking feature is the increase in average cost per patient day of 142 percent over the period. This amounts to a greater than 20 percent rate of increase annually, as compared to increases of 103 percent in total cost and 75 percent in total payroll over the same period. These figures provide evidence that salary expenditures are not primarily responsible for the rapid rise in average cost per patient day.

The table also indicates that average occupancy rate dropped six percentage points over the seven year period. The combination of falling occupancy rates and increasing average costs is consistent with the theory presented in Chapter 2. The decreasing occupancy rate is the result of a gradually increasing number of beds and a gradually

TABLE 3-6

ANNUAL MEANS OF SELECTED VARIABLES

	1971	1972	1973	1974	1975	1976	1977
Total Cost	$515,802	566,108	587,757	674,147	799,058	888,500	1,049,387
Total Payroll	297,920	312,752	325,698	353,880	420,039	458,829	523,218
Total Payroll / Total Cost	.58	.55	.55	.52	.53	.52	.50
AC/PD	62.45	73.44	77.91	92.67	106.09	126.45	151.25
Census	23.39	22.49	22.24	21.70	22.02	20.84	20.69
Total Beds	40.88	40.32	40.76	40.79	40.11	41.92	42.39
Occupancy Rate	.54	.52	.52	.51	.50	.49	.48
Long-Term Beds	6.73	6.88	7.44	7.52	7.62	8.35	8.66
Admissions	1239	1245	1233	1240	1289	1239	1267
Length of Stay	7.83	7.45	7.89	7.78	7.68	7.67	7.38

decreasing census. The average number of long term beds has increased over the period as has the ratio of long term to total beds, while total admissions have remained relatively stable and average length of stay has fallen slightly. It is possible that the data mask declines in lengths of stay for acute care, since the increase in long-term care beds would contribute to an increase in the overall average length of stay.

Summary Table of Means, Standard Deviations and Ranges. Table 3-7 is a summary table of all the variables used in the analysis along with their means, standard deviations and ranges. Variables for which no range is printed are binary variables. The mean for these variables represents the proportion of sample observations characterized by the presence of the variable. For example, approximately forty percent of the hospitals in the sample are organized under the county form of ownership and forty-four percent of the hospitals in the sample have postoperative recovery facilities. Definitions of variables that may need clarification are provided at the end of the table.

TABLE 3-7

MEAN, STANDARD DEVIATION AND RANGE OF ALL VARIABLES USED IN THE ANALYSIS

Variable:	Mean	Std. Dev.	Range
Size (in beds)	41.17	21.84	9-133
Size-squared	2171.3	2440.5	81-17,689
Occupancy[1]	.507	.170	.063-.969
Occupancy-squared	.287	.176	.004-.938
Length of Stay[2]	7.67	6.65	2.8-64.16
Accreditation	.32	.47	-
LTB/TB[3]	.15	.256	0-.873
Salary[4]	$6,158.70	$1,565.59	$2487-15,000
% Pop. over 65	10.59	3.18	4-19
Births/1000 population	192.64	46.67	89-355
AC/PD[5]	$99.38	$48.32	$14.73-331.85
Form of Ownership:			
County	.404	.491	-
City	.015	.120	-
City-County	.019	.138	-
H.D.A.[6]	.088	.283	-
Church Operated	.093	.290	-
Other	.356	.479	-
Corporation	.024	.154	-
Service and/or Facility:			
Postoperative Recovery	.44	.50	-
Intensive Cardiac Care	.30	.46	-
Intensive Care Unit	.46	.50	-
Pharmacy	.72	.45	-
Radiology	.14	.35	-
Histopathology	.09	.28	-
Blood Bank	.42	.49	-
Inhalation Therapy	.42	.49	-
Premature Nursery	.16	.37	-
Physical Therapy	.46	.50	-
Psychiatric Services	.11	.32	-
Organized Outpatient Services	.13	.34	-
Emergency Department	.83	.37	-
Social Services	.11	.31	-
Volunteers (Aux.)	.63	.48	-
Electroecephalography	.07	.26	-
Other Services	.25	.74	-
Other Medical Services	.01	.12	-

1 The occupancy rate is defined to be the average daily census divided by the average daily number of available beds.

2 Length of stay is defined to be total patient days divided by the number of admissions.

3 The ratio of long term beds to total beds.

4 Average salary is defined to be total payroll divided by the number of exployees.

5 Average cost per patient day is defined to be total expense divided by total patient days.

6 H.D.A. stands for Hospital District or Authority.

CHAPTER 4

EMPIRICAL RESULTS, POLICY IMPLICATIONS AND SUMMARY

The first section of Chapter 4 contains the statistical results of the analysis. Included are the pooled regressions for the linear, quadratic and log cost function specifications,[68] graphs of the long run and short run average cost curves, a table listing those services significantly affecting average cost per patient day, the regression results for different hospital groups (grouped on the basis of similar service/facility mix), an examination of the relationship between particular variables that appear to significantly interact (length of stay, the ratio of long-term to acute beds and the percentage of the population over age 65) and the regression results for hospitals without an attached long-term care facility.

The next section discusses the implications for policy (in regards to the optimal size and occupancy rates for rural hospitals) and provides information on the potential for savings for various combinations of hospital size and occupancy rate. This section also contains a brief discussion of areas for further research.

The last section of the chapter is a summary of the analysis, emphasizing some of the more important results for policy and planning.

Statistical Results. Tables 4-1 through 4-3 present the pooled regression results for the linear, quadratic and log specifications. Variables are added in stages in order to better understand the relationships between different independent variables and to determine which variables are "robust". Robustness refers to the degree to which the coefficient of a particular variable is impervious to changes in the cost function specification. It is a desirable quality because the more robust the coefficient, the greater the confidence one can place in the coefficient accurately reflecting the impact of the variable on average costs.

Significance is also a desirable characteristic of an estimated coefficient. It indicates the extent to which one can have confidence that the value of the coefficient is different from zero. Significance is reflected in the t-value in parenthesis below the coefficient. Following traditional norms, a coefficient will be considered significant if its t-value is greater than 1.96 (95 percent confidence level) and highly significant if its t-value is greater than 2.576 (99 percent confidence level).

The R^2 value indicates the extent to which the variation in average cost is explained by variation in the independent variables. A value of .73 means that 73 percent of the variation in average costs is explained by the specification under consideration. High R^2 values are desirable as measures of "goodness of fit", however it should be realized that adding independent variables to a specification always will increase R^2. Comparable R^2 values achieved by using fewer explanatory variables yield more efficient specifications of greater practical value.

Table 4-1 presents the results of the regression utilizing the linear cost function specification. The year variable is fairly robust while the occupancy variable is somewhat robust after the first stage. Year, occupancy, length of stay, accreditation, average salary and percent of the population over 65 are all highly significant explainors of the variation in average cost per patient day. R^2 is continually and significantly increasing with each addition to the model. The coefficient on the size variable does not attain significance until the linear model is fully specified (stage IV). This may reflect the importance of controlling for the service/facility mix. The coefficient is negative and highly significant indicating the potential existence of economies of scale in the hospital industry. The large negative coefficient on the occupancy variable also indicates the potential for cost reduction through increasing occupancy rates in rural hospitals. The results imply that longer lengths of stay tend to be associated with lower average costs per patient day, that accreditation and higher salaries result in higher average costs, higher ratios of long-term to acute beds are associated with lower average costs and that percent of the population over 65 and the number of births are inversely related to average costs.

TABLE 4-1

LINEAR SPECIFICATION RESULTS[†]

	I	II	III	IV
Constant	-802.19	-709.11	-705.53	-624.72
Year	12.87 (20.85)*	11.27 (17.07)*	11.91 (18.73)*	10.64 (16.72)*
Size	.119 (2.10)*	-.023 (-0.43)	.0014 (.026)	-.306 (-4.64)*
Occupancy	-114.57 (-15.44)*	-83.53 (-11.75)*	-85.82 (-12.45)*	-97.44 (-13.83)*
Length of Stay		-1.98 (-11.0)*	-1.56 (-7.29)*	-1.39 (-6.74)*
Accreditation		11.92 (4.78)*	10.57 (4.38)*	7.69 (3.28)*
Average Salary		.0046 (5.28)*	.0034 (4.11)*	.0031 (3.87)*
Long-Term Beds / Total Beds			-18.13 (-3.37)*	-10.14 (-1.92)
% Population Over 65			-2.84 (-7.87)*	-2.11 (-5.99)*
Births/1000 Population			-.073 (-2.99)*	-.053 (-2.22)*
R^2 =	.52	.64	.67	.72
Postoperative Recovery				7.29 (3.19)*
Intensive Cardiac Care				1.12 (0.50)
Intensive Care Unit				12.52 (5.41)*
Pharmacy				-1.38 (-0.59)
Radiological Services				-0.82 (-0.27)
Histopathology Lab				20.98 (5.18)*
Blood Bank				1.44 (0.66)
Inhalation Therapy				0.80 (0.31)
Premature Nursery				1.42 (0.50)
Physical Therapy				-0.25 (-0.09)
Psychiatric Services				5.67 (1.67)
Outpatient Services				-4.82 (-1.61)
Emergency Department				6.39 (2.22)*
Social Services				-8.28 (-2.34)*
Volunteers				8.50 (3.69)*
Electroencephalography				4.80 (1.23)
Other Services				-1.73 (-1.12)
Other Medical Services				18.43 (2.28)*

[†] Values in parentheses are t-values.

* Significant at the .95 level of significance.

Table 4-2 presents the results of the quadratic specification. When the model is fully specified the coefficient on the size variable is negative and highly significant while the coefficient on size-squared is positive and significant at the 94 percent confidence level. The coefficients on the occupancy and occupancy-squared variables are negative and positive respectively and both highly significant. The remaining variables in the quadratic specification have the same general impact on average cost per patient day as they had in the linear specification.

Table 4-3 presents the results of the log specification. Using dummy variables for the years in the study provides estimates of the annual rates of inflation over the period. The indicated average rate is 9.0 percent. The trend is towards increasing annual rates with a rate of 7.1 percent for the first year, 4.1 percent for the second, 10.6 percent for the third, 9.5 percent for the fourth, 10.2 percent for the fifth and 12.5 percent for the sixth year. This specification also indicates the potential for economies of scale and a reduction in average costs through increased occupancy rates. The other variables in the model once again have the same general effect on average cost as in the linear and quadratic specification, however the natural log specification appears to provide a higher degree of explanatory power (R^2 = .84) than either the linear (R^2 = .72) or the quadratic (R^2 = .75) specification. This suggests that the logged model fits the data