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A THEORY OF ECONOMIC BEHAVIOR IN NON-PROFIT, PRIVATE HOSPITALS

by

Karen Davis

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CHAPTER 1

Introduction

The short-term hospital industry in the United States is characterized by non-profit ownership. In 1966, seventy-two percent of short-term, general admissions took place in voluntary, non-profit hospitals, seven percent in proprietary hospitals, and twenty-one percent in local and state hospitals. Very little is known, however, about how economic decisions are made in non-profit organizations. The applicability of standard economic models based upon the assumption of profit-maximizing firms to a market dominated by non-profit organizations is questionable.

Several characteristics of the market for hospital care make it an especially important area for study. Daily service charges for hospital care have doubled in the last ten years. In the eighteen month period following the implementation of Medicare in July, 1966, daily service charges increased by twenty-nine percent. Utilization of hospital services has also increased in recent years. In 1965, persons aged sixty-five and over increased utilization of hospital bed-days by seven

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percent. In 1967, total number of patient days of persons aged sixty-five and over increased by twenty-two percent. Non-profit, private hospital revenue has increased from $4.3 billion in 1960 to $9.2 billion in 1967. Net revenue has increased from $116 million in 1960 to $339 million in 1967. Provision of hospital services is becoming an increasingly profitable industry.

Because of the importance of understanding behavior in the hospital industry, this study will develop and test a theoretical model of pricing and investment behavior applicable to non-profit, private hospitals.

The plan of this study is as follows. Chapter 2 reviews theoretical and empirical work on the characteristics of the demand for hospital care. In addition three behavioral motivations of the suppliers of hospital care suggested in the literature are examined in detail: recovery of costs, output maximization, and utility maximization. Implications of these motivations for pricing and investment determination are derived.

Chapter 3 develops a model of output and investment determination based upon five major hypotheses: 1) demand for a hospital's services depends upon the hospital's capital stock,

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3 American Hospital Association, Hospitals, Guide Issue, XXXV (August 1, 1961) and XLII (August 1, 1968).
2) short-run costs vary with capital stock, 3) prices are set so as to maximize net patient revenue, 4) all net patient revenue is invested, and 5) investment funds are allocated so as to maximize future net patient revenue. This model of behavior is applied to derive implications of the impact of Medicare upon prices charged private patients, internal rate structures, cash flow of various sized hospitals, and future capital investment.

Chapter 4 subjects the five major hypotheses formulated in Chapter 3 to empirical testing. Ordinary least-squares regression analysis is employed in investigating the effect of specialized facilities on demand for hospital services. After reviewing previous attempts in the literature to estimate hospital cost curves, a method is devised for examining the effect of various types of capital on short-run costs of providing hospital services. The hypothesis that prices are simply set equal to average costs is tested and rejected. Although data on various types of capital investment leave much to be desired in quality and quantity, some evidence on the determinants of capital investment and composition of investment is analyzed. The empirical analysis concludes with a two-stage least-squares estimation of a simultaneous equation model of output and factor input determination.

Chapter 5 summarizes findings of the study and compares implications of the model with initial experience under the Medicare program.
It should be noted that analysis is restricted to a fairly homogeneous group of hospitals: short-term, private, non-profit hospitals. Special long-term hospitals such as psychiatric or tuberculosis hospitals are excluded. Governmental hospitals (federal, state, and local) and proprietary hospitals are excluded since these hospitals may have different incentives and motivations. Non-profit refers to the legal restriction prohibiting the distribution of profits to owners. It should not be interpreted as implying that the organization makes no profits or that the organization attempts on the average to make no profits.
CHAPTER 2

Pricing, Output, and Investment Determination in Non-Profit, Private Hospitals: A Review

2.1 Demand for Hospital Care

2.1.1 Theoretical Aspects

Until recent years the influence of economic factors upon the demand for hospital care was completely neglected. The demand for hospital care was depicted as perfectly price inelastic. If hospital care was medically necessary it would be obtained regardless of price charged for care. Rosenthal, for example, points out

"In general, the role of hospital charges in determining the utilization of hospitals has been ignored except in discussion relating to insurance, which is an implicit price variable. The nonprofit nature of most of the general hospitals, coupled with the myth that all who need hospital care will receive it, has precluded any serious examination of the effect of price on the demand for care." ¹

The view that demand for hospital services is perfectly price inelastic is also held by many hospital administrators. In an interview study of hospital administrators, Kaitz reports

"The four administrators of urban and suburban hospitals stated that the consumer was price-insensitive

and that price increases or decreases would not encourage or discourage the demand for hospital services."

The main reason for rejecting economic factors as influencing demand for hospital care seems to be based upon the argument that the decision to hospitalize is made by the physician, not by the patient. Since no one can be admitted to a hospital without the signed statement of a physician that hospitalization is medically required, quantity of services demanded is simply that which is medically necessary. This position is held by the American Medical Association:

"The physician, then, plays a key role in determining the effective demand for hospital services. And since his decisions to request the services of a hospital are made on medical grounds, suppliers of hospital care must react to a market place which is, in many respects, unique." 4

Even though the physician makes the final decision regarding hospitalization, economic variables may influence this decision in a number of ways. First, high prices charged for hospital care, low incomes, or absence of insurance coverage may keep the individual from even seeking hospital care except in cases of extreme medical necessity. For example, a patient


3 For a discussion of the needs approach to the demand for hospital care, see Mark Vincent Pauly, Efficiency in Public Provision of Medical Care, Unpublished doctoral dissertation, University of Virginia, 1967.

with pneumonia may elect to hire a private nurse and be cared for at home if daily hospital charges are very high.

Second, even if the doctor makes the hospitalization decision, he may take the patient's economic condition into consideration. For example, P. Feldstein argues that the patient's economic circumstances may influence the method used to treat the patient:

"In treating this illness the physician is aware of the patient's financial resources and how much he can afford to spend, and this, in addition to the physician's medical knowledge (and other constraints to be discussed), influences the kinds of 'inputs' he will prescribe."

Third, if the doctor is affiliated with several hospitals, patients may examine prices charged at various hospitals in selecting a hospital. As Klarman indicates

"A lower rate may serve to attract patients to a hospital if their physician is associated with several hospitals and offers his patients a choice among them. This situation obtains most frequently in maternity care."

Even if doctors are associated with only one hospital, large differences in prices charged by different hospitals may influence the patient's choice of a physician.


Fourth, high prices charged for hospital care, low incomes, or absence of insurance coverage may cause the patient to influence physician's decision regarding the length of stay in the hospital. This seems to be particularly true of maternity cases:

"Prices and income theoretically affect not only a person's decision whether or not to seek medical care, but also the extent of the care once treatment is undertaken. For example, the effect of prices or of income may or may not have much effect on whether or not a maternity patient goes to the hospital (although it may influence the choice of hospital), but once she has been admitted, it may affect the length of her stay."

In spite of the widespread belief that demand for hospital services is perfectly price inelastic, it is also a widespread belief that hospitalization insurance tends to increase utilization. That is, a reduction in the net price to be paid by the patient leads to an increase in the quantity demanded. Numerous studies have verified the validity of the view that insurance coverage leads to greater utilization. Surveys by Anderson and others reveal that insured individuals have higher admission rates than uninsured. Somewhat more sophisticated studies comparing groups similar in respects other than insurance coverage also revealed greater utilization among insured

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7 Paul J. Feldstein, p. 146.
Densen, Balamuth, and Shapiro found higher hospitalization rates among individuals whose insurance covered physician fees only if the individual was hospitalized—lending some support to the view that physicians take the patient's economic condition into consideration in making the decision to hospitalize.

2.1.2 Empirical Studies

Rosenthal's pioneering empirical study of the demand for hospital care shed some light on the importance of various economic and sociodemographic variables. Results of his ordinary least-squares regression estimations based upon cross-state data in 1950 and 1960 are shown in Table 1.

In both 1950 and 1960 Rosenthal found price (average charge for a two-bed room) to be negatively related to patient days, although the coefficient was insignificant in 1950. Percent of population with incomes above $5,999 entered with a positive coefficient. This measure of income is significant, however, only in the pooled 1950 and 1960 data regression. For

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10 Paul M. Densen, Eve Balamuth, and Sam Shapiro, Prepaid Medical Care and Hospital Utilization (Chicago: American Hospital Association, 1958).

**TABLE 1: ROSENTHAL'S DEMAND RELATIONSHIPS FOR 1950 AND 1960**  
**DEPENDENT VARIABLE: PATIENT DAYS PER 1000 POPULATION**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>1950</th>
<th>1960</th>
<th>1950 &amp; 1960</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>11,578.5</td>
<td>110.14</td>
<td>5,090.2</td>
</tr>
<tr>
<td>Charges for 2-bed room</td>
<td>-30.99</td>
<td>-39.09***</td>
<td>-30.70***</td>
</tr>
<tr>
<td></td>
<td>(19.19)</td>
<td>(8.72)</td>
<td>(7.64)</td>
</tr>
<tr>
<td>Per cent over $5999 income</td>
<td>11.96</td>
<td>5.43</td>
<td>12.26***</td>
</tr>
<tr>
<td></td>
<td>(19.95)</td>
<td>(5.79)</td>
<td>(3.78)</td>
</tr>
<tr>
<td>Per cent under $2000 income</td>
<td>-21.22***</td>
<td>14.24 **</td>
<td>12.00***</td>
</tr>
<tr>
<td></td>
<td>(7.34)</td>
<td>(6.82)</td>
<td>(3.53)</td>
</tr>
<tr>
<td>Per cent hospital coverage</td>
<td>-0.76</td>
<td>5.83***</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>(2.12)</td>
<td>(2.13)</td>
<td>(1.46)</td>
</tr>
<tr>
<td>Per cent over age 64</td>
<td>-41.07</td>
<td>22.83</td>
<td>5.48</td>
</tr>
<tr>
<td></td>
<td>(40.86)</td>
<td>(25.28)</td>
<td>(21.78)</td>
</tr>
<tr>
<td>Per cent under age 15</td>
<td>13.38</td>
<td>23.69</td>
<td>18.19</td>
</tr>
<tr>
<td></td>
<td>(23.50)</td>
<td>(21.11)</td>
<td>(14.71)</td>
</tr>
<tr>
<td>Per cent of females married</td>
<td>-90.45***</td>
<td>84.44***</td>
<td>75.43***</td>
</tr>
<tr>
<td></td>
<td>(19.41)</td>
<td>(16.44)</td>
<td>(12.05)</td>
</tr>
<tr>
<td>Per cent male</td>
<td>17.80</td>
<td>156.75***</td>
<td>72.28***</td>
</tr>
<tr>
<td></td>
<td>(32.80)</td>
<td>(33.69)</td>
<td>(22.53)</td>
</tr>
<tr>
<td>Per cent in urban areas</td>
<td>-12.67***</td>
<td>-0.31</td>
<td>-6.30***</td>
</tr>
<tr>
<td></td>
<td>(3.79)</td>
<td>(2.37)</td>
<td>(1.94)</td>
</tr>
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<td>Per cent over 12 yrs. education</td>
<td>5.12</td>
<td>4.22</td>
<td>3.25</td>
</tr>
<tr>
<td></td>
<td>(12.16)</td>
<td>(8.01)</td>
<td>(6.89)</td>
</tr>
<tr>
<td>Per cent nonwhite</td>
<td>8.49**</td>
<td>1.89</td>
<td>3.74</td>
</tr>
<tr>
<td></td>
<td>(4.20)</td>
<td>(3.36)</td>
<td>(2.50)</td>
</tr>
<tr>
<td>Population per dwelling unit</td>
<td>1166.33***</td>
<td>-507.92</td>
<td>-726.67***</td>
</tr>
<tr>
<td></td>
<td>(384.48)</td>
<td>(321.52)</td>
<td>(227.41)</td>
</tr>
<tr>
<td>Time Period</td>
<td></td>
<td></td>
<td>322.50**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(119.86)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.80</td>
<td>0.77</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Standard errors in parentheses.
* Significant at 10% level; ** Significant at 5%; *** Significant at 1%.

Source: G. Rosenthal, *Demand for General Hospital Facilities*, Table 3, p. 35 and Table 5, p. 42.
states with higher percentage of population with incomes below $2,000, demand for hospital care is significantly lower both in 1950 and in 1960.

Insurance coverage is significantly related to patient days in 1960, but not 1950. Part of the explanation for this result may be attributable to the fact that insurance benefits were broader in 1960 with insurance paying a more significant part of the total bill. In 1960, then, a greater difference in demand for hospital care would be expected between insured and non-insured groups.

The most important sociodemographic variables were percent of the state's female population married and population per dwelling unit. The negative significance of these variables suggests that when individuals are available at home to care for patients home care is an effective alternative to hospital care.

Three major objections may be made to the Rosenthal study. The first weakness concerns the choice of the price variable. Ideally, the price variable would be the net price paid by the patient rather than the price charged by the hospital. Instead of using price charged and per cent of population covered by insurance to approximate net price, appropriate construction of the price variable would directly net out the contribution of
insurance. As P. Feldstein emphasizes:

"To estimate a price effect empirically, a 'net' price variable must be used, that is, the 'out-of-pocket' price to the patient and not the stated price. To arrive at this estimate, the effect of health insurance, 'free' care and the tax deductibility aspects would first have to be eliminated." 12

Unfortunately, the necessary data to make this calculation were not available for the sample used by Rosenthal.

The second weakness is the neglect of the supply side. The problem of identification, long recognized in estimating demand and supply curves, is ignored. 13 The observed relationship between quantity of hospital services and price may be the demand curve, the supply surue, or some mongrel combination of both. Without a theory of supply, single equation estimation of the demand equation may yield inconsistent estimates. 14

A somewhat similar objection stems from the possibility of non-price rationing, either on the part of the hospital or

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14 Under some conditions, single equation estimation of the demand equation would be legitimate. For example, if the supply equation did not contain both price and quantity, the simultaneous equation system would be recursive, and the demand equation could be estimated separately.
the physician. To the extent that demand is greater than bed capacity at the prevailing price, quantity observed will be less than quantity demanded, and observed points will not lie on the "true" demand curve. M. Feldstein argues that as hospitals approach maximum capacity use, physicians ration hospital space by diverting more patients to out-patient care and by shortening lengths of stay:

"All manifest demand methods are subject to the same criticism: they ignore the effect of available bed supply on the demand for hospital admission and on the average duration of stay per case. Where beds are scarce and waiting lists long, more work is done on an out-patient basis and the length of stay is relatively short; if the number of beds is increased, the hospitalization rate and the length

15

The assertion, frequently made in the medical literature that supply creates its own demand has led to considerable confusion. Roemer and Shain present as evidence (that increased bed capacity causes increased patients) the trend over time for cases of lower "medical urgency" to be treated in the hospital: "A half century ago only the most desperately ill were hospitalized; cases of pneumonia, tonsillectomies, deliveries, heart attacks, fractures were treated at home or in the doctor's office. Today not only are these cases hospitalized, but so are cases of multiple-tooth extractions, psychoneurosis, epilepsy, diabetes for insulin stabilization, or any obscure condition for diagnosis. All this is made possible by an increase in the relative supply of beds, and reciprocally it creates pressures for continual expansion of the bed capacity." Milton I. Roemer and Max Shain, Hospital Utilization Under Insurance (Chicago: American Hospital Association, 1959), p.12.

This is exactly the type of behavior, however, which would be expected if incomes were to rise over time. With low standards of living, a small quantity of hospitalization would be demanded (only for severe cases). With higher standards of living, more hospitalization would be demanded (including that for less urgent needs). This in no way proves that the bed capacity has itself caused the increased demand.
of stay also increase.... his [Rosenthal's] use of the regression equations to study the influence of social and economic factors on the demand for hospital care is questionable. The omission of bed supply from the bed use ('demand') equations is a serious misspecification that is likely to have sizeable effects on each of the other coefficients." 16

The version of the "supply creates its own demand" argument presented by M. Feldstein is a more sophisticated one. If hospitals are operating close to capacity and if quantity of hospital days demanded at the existing price exceeds available bed capacity, then physicians ration the available space by treating more patients in the office or on an out-patient basis. In such a case increasing bed capacity would eliminate or reduce such rationing and observed quantity demanded would increase. The interpretation in this case is not so much that increased bed capacity causes an increase in quantity demanded, but rather absence of sufficient capacity keeps observed quantity demanded less than "true" quantity demanded (i.e. less than it would be in the absence of rationing).

Feldstein's criticism of Rosenthal's estimation, then, is unfounded if non-price rationing by the physician or hospital does not exist for the hospitals in the sample. 17 In the absence of

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Rosenthal does check for the possibility that increased supply does lead to increased demand. He constructed a pressure index, based upon the ratio of observed occupancy rate to maximum occupancy rate. Increases in supply of hospital beds did not cause sufficient increase in demand to leave the index unchanged.
rationing all observed points would lie on the "true" demand curve.

P. Feldstein conducted a similar demand estimation based upon data obtained in a 1958 consumer survey conducted by the Health Information Foundation and the National Opinion Research Center. Results of his estimation are as follows:

\[
\text{Hospital Patient Days} = -12.653 + .0005 \text{ Family Income} \\
+ .1495 \text{ Age of Head} + .0305 \% 65 \text{ Years Plus} + .0644 \% \text{ Under 5 Years} \\
+ .0212 \% \text{ Family Single} + 1.464 \text{ Family Size} - .0460 \text{ Education} \\
- .0166 \text{ Free or Reduced Care} + .0121 \% \text{ Urban} - .0433 \text{ Price} \\
+ .0598 \% \text{ Insurance} \quad R = .42
\]

Price enters with a negative coefficient, which is statistically insignificant. Insurance, a proxy price variable, however, is positively related to quantity demanded suggesting that a significant relationship between price and quantity might be observed if the appropriate net price variable could be constructed.

18 In Feldstein's study of the British National Health Service in which consumers of hospital care face a zero price, considerable non-price rationing is likely to exist. It is not too surprising, therefore, that M. Feldstein's empirical studies indicate that an increase in bed capacity would lead to an increase in observed quantity demanded (what Feldstein refers to as manifest demand). Feldstein, Economic Analysis for Health Service Efficiency, Ch. 7.

19 Feldstein, "The Demand for Medical Care." For additional information on data see Anderson and Feldman, Changes in Family Medical Care Expenditures and Voluntary Health Insurance.
All of the objections to the Rosenthal study mentioned above apply as well to the Feldstein study. In addition, the price variable used by Feldstein is derived indirectly by dividing total expenditures for hospital services by quantity of services.

2.2 Pricing Policy of Suppliers of Hospital Services

The supply side of the hospital market has been largely neglected. Traditionally, supply has been equated with number of facilities available (i.e. number of beds, number of hospitals) rather than in the economic sense of supply as quantity suppliers desire to supply given demand conditions.

Perhaps because suppliers of hospital care are largely non-profit organizations (in the legal sense that owners may not receive dividends), it has been assumed that hospital administrators pursue goals other than profit maximization. Weisbrod, for example, dismisses profit maximization because "public opinion opposes profit."\textsuperscript{20} Long and Feldstein also assert that hospitals do not attempt to maximize profits:

"Instead of maximizing profits, hospitals seek to optimize some complex, differing, and, for most institutions, ill-defined goal subject to certain financial constraints. Commonly, hospitals attempt to 'break even' on operating account."\textsuperscript{21}


In the following sections three behavioral motivations of hospitals suggested in the literature will be reviewed: 1) recovery of costs, 2) output maximization, and 3) utility maximization. Implications of these motivations for pricing and investment determination will then be derived.

2.2.1 Recovery of Costs

The most prevalent view of prices is that the price of each service is set equal to the average cost of providing the service. This view of hospital pricing is based upon the assumption that non-profit organizations are interested only in serving the public and have no desire to make any profits. In a recent book, Ingbar and Taylor depict the non-profit hospital as an organization aiming primarily to recover its costs:

"The typical short-term hospital is not interested in making a profit as such. Being a voluntary and charitable institution, it is content to cover its costs and sets its charges accordingly; to the extent that revenues (those charges actually collected) fall short, the difference is donated by some interested third party... It is obvious, therefore, that the revenues and charges of a hospital can not be analyzed in the same way as the income and pricing policy of, say, a steel company."  

Guidelines for pricing hospital services set forth by the American Hospital Association also emphasize setting prices at

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a level which will recover total costs. Included in the guidelines is an allowance for capital expansion so that prices would include a percentage markup over costs. Factors to evaluate in the establishment of charges outlined by the American Hospital Association are as follows:

1. Charges for services to patients should cover current operating expenses applicable to their care.

2. Charges for services to patients should include an appropriate factor to cover current operating expenses applicable to the care of those patients who give rise to credit losses (bad debts).

3. Charges for services to patients should include an appropriate factor for the net expenses of educational programs.

4. Charges for services to patients should include an appropriate factor to provide the funds required to preserve plant capital (depreciation based upon current cost of replacement).

5. Charges for services to patients should include an appropriate factor to cover the funds necessary for plant expansion due to improvement of services required to keep pace with technological and scientific advances.

6. Charges for services to patients should include an appropriate factor to provide the funds required to protect the hospital against the effects of unforeseen adverse economic conditions.

7. Charges for services to patients may include a reasonable factor to cover the unreimbursed portion of the expenses of research programs, community health programs, etc.

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Essentially, the guidelines suggest that total revenue should equal total costs plus investment expenses (or equivalently, total revenue less total costs should equal investment expenses).

This view of the price-setting process is also set forth by Kaitz based upon an interview study of hospital administrators:

"The price-setting process can at best be termed passive. Prices are simply set higher than costs.... Its sole purpose is to provide the hospital with sufficient income to meet its total costs plus whatever profit might be desired."

Given that hospitals set the price of a hospital service at a percentage of its cost, the important question is what determines the amount of markup. If the markup is solely

---

Kaitz, Pricing Policy and Cost Behavior in the Hospital Industry, p. 66.

determined on the basis of what is needed for investment, how is the "needed" investment determined? Do competitive pressures play a role in determining the markup?

The internal rate structure could give some evidence on this question. If competitive factors are more important for some services than others, different markups on different services would be expected. If competitive pressures are unimportant, prices on all services could be marked up uniformly. The latter is, in fact, the policy recommended by the American Hospital Association:

"The rate charged for each individual service should reflect properly the operating expenses of the service rendered plus an equitable share of the other financial needs for which the patient is responsible." 26

McNerney found that in practice hospitals do not follow this recommendation. In four Michigan hospitals, room charges varied from 91.4 to 115.5 per cent of average cost. Laboratory rates varied from 149.9 to 212.5 per cent of average cost, and pharmacy rates varied from 215.0 to 284.5 per cent of average cost. 27

Part of the diversity of markups may be attributed to competitive pressures. Kaitz, for example, reports:

26 American Hospital Association, Factors to Evaluate in the Establishment of Hospital Charges, p. 10.
27 Walter J. McNerney and Study Staff, Hospital and Medical Economics (Chicago: Hospital Research and Educational Trust, 1962) p. 923.
"Each of the six hospital administrators stated that the cost of providing a service is the initial base upon which prices are set.... The prices established from these standards are subsequently modified for competitive factors.... Each of the administrators stated that the price for routine services (room and board) was set as close to its formula-computed cost as possible because of the competition between hospitals for patients." 28

The desirability of setting prices of services at a fixed percentage of average cost seems to be based upon the opinion that it is a "fair" method of allocating costs of care among patients. Patients only pay for the costs of those services which they receive (plus an allowance for future capital expansion). But if hospitals were to follow the American Hospital Association's recommendation, the important rationing function of prices would be destroyed. For example, hospitals with excess capacity in the maternity department would not be able to reduce delivery room rates to induce more patients to choose their hospitals. Instead with a lower quantity being demanded and a declining short-run average cost curve, the hospitals would have to charge higher prices according to the cost-plus scheme. Hospitals with a large number of patients (and concomitant lower average costs) would charge a lower price. If quantity demanded exceeded capacity at that price,  

prices could not be raised to ration available facilities.

2.2.2 Output Maximization

A different objective of non-profit hospitals has been proposed by Long:

"Short-term general hospitals are typically organized as independent units under the control of self-perpetuating boards of directors. Profit maximization is clearly not the force directing their behavior. Insofar as I have been able to determine it, the guiding principle is a desire to maximize the number of patients seen subject to several constraints. There is a financial limit specified by the sponsoring agency." 30,31

Klarman has also noted this objective:

"It has been postulated that a voluntary hospital aims to maximize the welfare of society by serving as many patients as possible, subject to certain constraints. One is that the size of its deficit cannot exceed specified limits." 32

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29 An area-wide program to revise internal rate structures to correspond closely with costs is reported by Susan S. Jenkins, "Development of Charges in Relation to Costs by Kansas City Area Hospital Association," in Third-Party Reimbursement for Hospitals (Bloomington, Ind.: Indiana University, 1965). Jenkins emphasizes that with the new method hospitals charge different prices for the same service.


31 This differs from the sales maximization motivation developed by William J. Baumol, Business Behavior, Value and Growth (New York: The Macmillan Company, 1959). In Baumol's model sales revenue is maximized (price times quantity); here physical output is maximized (quantity).

32 Klarman, The Economics of Health, p. 121.
A modified version of this motivation has been suggested by Reder. He asserts:

"hospitals ... tend to be run as though their objective was to maximize the weighted number of patients treated (per time period), the 'weights' being the professional prestige of the doctors attending them." 33

If the hospital operated subject to a constraint of breaking even and produced only one product, price would be set equal to average cost at expected output just as in the average cost model. Hospitals, however, are multiproduct firms so that prices of services (such as ancillary services) which have little effect on number of patients treated could be raised to positive profit levels. The profits on ancillary services could then be used to subsidize losses on room services (since reduction in room rates could be expected to increase number of patients served). This would give one explanation of the internal rate structure found by McNerney. 34

Implications of the output maximization motivation for the internal rate structure may be formally derived with the help of the following simple model.

Suppose that the hospital produces two services: routine room services measured in number of patient days and ancillary

34 See p. 20 above.
services. For simplicity it will be assumed that demand for room services depends only upon the price of room services and demand for ancillary services depends only upon the price of ancillary services. The cost of producing the two services is assumed to be separable.

Let \( P_r = P_r(X_r) \) be the demand for routine room services, \( P_a = P_a(X_a) \) be the demand for ancillary services, and
\[
C = TFC + TVC_r(X_r) + TVC_a(X_a)
\]
be total cost of producing both services where \( TFC \) = total fixed costs, \( TVC_r \) = total variable costs of producing routine services, and \( TVC_a \) = total variable costs of producing ancillary services.

Maximizing number of patient days subject to the financial constraint of breaking even yields the following:

\[
\text{Max. } L^* = X_r + \lambda (P_r X_r + P_a X_a - TFC - TVC_r - TVC_a)
\]

1) \[
\frac{\partial L^*}{\partial X_r} = 1 + \lambda (P_r + X_r \frac{\partial P_r}{\partial X_r} - \frac{\partial TVC_r}{\partial X_r}) = 1 + \lambda (MR_r - MC_r) = 0.
\]

2) \[
\frac{\partial L^*}{\partial X_a} = \lambda (P_a + X_a \frac{\partial P_a}{\partial X_a} - \frac{\partial TVC_a}{\partial X_a}) = \lambda (MR_a - MC_a) = 0.
\]

3) \[
\frac{\partial L^*}{\partial \lambda} = P_r X_r + P_a X_a - TFC - TVC_r - TVC_a = 0.
\]

See Appendix A for analysis of the general case with \( n \) services and interdependent demands.
Therefore,

1') \( \lambda = \frac{1}{MC_r - MR_r} \)

2') \( MR_a = MC_a \)

3') \( P_a X_a - TVC_a - TFC = TVC_r - P_r X_r \)

where \( MR_r \) = marginal revenue on routine services, \( MC_r \) = marginal cost of producing routine services, \( MR_a \) = marginal revenue on ancillary services, and \( MC_a \) = marginal cost of producing ancillary services.

Ancillary services are priced so as to yield a maximum profit (i.e. marginal revenue on ancillary services is equated to marginal cost). From equation (3'), all profits on ancillary services in excess of fixed costs are used to subsidize losses on room services. Determination of the level of output of room services is depicted in Figure 1. Let \( \pi_a^* = P_a X_a^* - TFC - TVC_a^* \) where \( X_a^* \) is that level of ancillary service output at which marginal revenue equals marginal cost and \( TVC_a^* \) is total variable cost of producing that level of ancillary service output. Let \( \pi_r^* = P_r X_r^* - TVC_r \). Optimal output of \( X_r^* \) is determined where \( \pi_r = \frac{1}{\lambda} \).

Output of room services is always greater than it would be if the hospital were to maximize profits, \( (X_r^* \) is to the right of \( X_r^0 \) in Figure 1).
\[ \pi_r = p_r x_r - TVC_r \]
The implication that patients are "overcharged" for ancillary services and "undercharged" for routine room services may be seen somewhat more clearly by considering the following simple example:

**Demand equations:**

Room services \( P_r = 10 - X_r \)

Ancillary services \( P_a = 20 - 4 X_a \)

**Cost equation:**

\[ C = 4 X_r + 4 X_a \]

Maximizing number of patients served yields:

Max. \( L^* = X_r + \lambda (10 X_r - X_r^2 + 20 X_a - 4 X_a^2 - 4 X_r - 4 X_a) \)

1) \( \frac{\partial L^*}{\partial X_r} = 1 + \lambda (6 - 2X_r) = 0 \)

2) \( \frac{\partial L^*}{\partial X_a} = \lambda (16 - 8X_a) = 0 \)

3) \( \frac{\partial L^*}{\partial \lambda} = 6X_r - X_r^2 + 16X_a - 4 X_a^2 = 0 \)

From (1), \( \lambda = \frac{1}{2X_r - 6} \)

From (2), \( X_a = 2, P_a = 12, \Pi_a = 24 - 8 = 16. \)

From (2) and (3), \( X_r = 8, P_r = 2, \Pi_r = 16 - 32 = -16. \)

Solution is shown in Figure 2. The equilibrium price of ancillary services is $12 with an output of 2 units and total cost
FIGURE 2
of $8 so that a $16 profit on ancillary services results. Equilibrium price of room services is $2 with an output of 8 units and cost of $32 so that a $16 loss is made on room services.

The $16 profit on ancillary services is used to subsidize the $16 loss on rooms, and the hospital breaks even.

Note that an exogenous increase in demand for ancillary services which increases profit on ancillary services will lead to a reduction in the price of rooms.

2.2.3 Utility Maximization

Since administrators of non-profit hospitals are legally prevented from distributing profits, it has been suggested that administrators maximize their own utility. According to Reeder, the administrator's utility is a function of the size of the hospital, extensiveness of modern equipment, and professional prestige of doctors on the staff, i.e. $U_1 = U_1(K,D)$ where $K$ is hospital capital and $D$ is a weighted sum of doctors on staff with

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37 Reeder,"Some Problems in the Economics of Hospitals."
the weights being professional prestige. 38

Reder also argues that the hospital's ability to attract and retain doctors on its staff is a function of the range of capital equipment of the hospital:

"Because doctors can admit patients into only one or two hospitals, they have an incentive to become affiliated with hospitals which are as fully equipped as possible, so that they may treat hospitalized patients for as wide a range of ailments as their competence (as they judge it) permits.... Hospitals that wish to attract men of outstanding qualifications to their staffs are therefore impelled to expand the inventory of their equipment and the range of services they are able to offer. This serves to reinforce the usual prestige motives for expansion and improvement inherent in any organization." 39

Since the number of doctors on the staff can be expressed as a function of the hospital's specialized capital equipment, i.e. $D = D(K)$, the utility function may be rewritten as $U_2 = U_2(K)$.

It is possible that administrators also derive utility from providing services as well as simply having the facilities and equipment available so that $U = U(X,K)$ where $X$ is output of hospital services.

A simple model will illustrate the implications of utility maximization for pricing of output and acquisition of capital. As before, let $P = P(X)$ be the demand for hospital services. In

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38 See Appendix B for treatment of more than one type of capital.

addition, let $X = F(K,L)$ be the production function relating inputs of capital and labor to output of hospital services.

Then maximizing the utility function subject to the financial constraint of zero total profits and the technological constraint of the production function yields the following:

Max. $U^* = U(X,K) + \lambda (P(X) X - wL - rK) + \mu (F(K,L) - X)$

1) $\frac{\partial U^*}{\partial X} = \frac{\partial U}{\partial X} + \lambda (P(X) + X \frac{dp}{dx}) - \mu = 0$

2) $\frac{\partial U^*}{\partial L} = -\lambda w + \mu \frac{\partial F}{\partial L} = 0$

3) $\frac{\partial U^*}{\partial K} = \frac{\partial U}{\partial K} - \lambda r + \mu \frac{\partial F}{\partial K} = 0$

4) $\frac{\partial U^*}{\partial \lambda} = P(X) X - wL - rK = 0$

5) $\frac{\partial U^*}{\partial \mu} = F(K,L) - X = 0$

From 2), $\mu = \frac{\lambda w}{\partial F/\partial L}$

Therefore, from 1), $\lambda = \frac{\partial U/\partial X}{w/\partial F/\partial L - MR}$

where $MR = P(X) + X \frac{dp}{dx}$

And from 3), $\lambda = \frac{\partial U/\partial K}{r + w \frac{dL}{dK}}$ for given $X$ since

$$dF = \frac{\partial F}{\partial K} dK + \frac{\partial F}{\partial L} dL = 0$$ implies $\frac{dL}{dK} = -\frac{\partial F/\partial K}{\partial F/\partial L}$

Combining the above results gives:

6) $\frac{\partial U/\partial X}{w/\partial F/\partial L - MR} = \frac{\partial U/\partial K}{r + w \frac{dL}{dK}}$
Equation (6) may be interpreted as equating the marginal utility of output per extra dollar cost of another unit of output to the marginal utility of capital per extra dollar cost of another unit of capital. To see this, consider the denominator of the left hand side of equation (6). If output is increased one unit while capital is held constant, cost goes up by the wage rate times the amount of labor required to produce one unit of output \( (w \frac{\Delta L}{\Delta X}) \) or \( w/\partial F/\partial L \), and revenue goes up by marginal revenue \( (MK) \) so that the net cost of an extra unit of output is the denominator of the left hand side of equation (6). On the other hand, if output is held constant and capital is increased by one unit, cost goes up by rate of return on capital times increase in capital and down by the wage rate times decrease in required labor (since less labor is required to produce the same amount of \( X \) is more capital is acquired). Net cost of extra unit is then \( r \, dK + w \, dL \) or \( dK(r + w \, dL/dK) \). (Note the \( dL \) is negative so that \( w \, dL \) represents a reduction of cost.)

A geometric exposition may elucidate this model. In equilibrium, total revenue equals total cost by the first constraint, but this does not necessarily determine output inasmuch as various levels of output need not be produced at minimum cost. In particular, excessive amounts of capital may be used to produce output since capital adds to utility.

A breakeven locus of capital–output combinations may be constructed by finding for every output level the amount of capital at which profits are zero. For each isoquant (such as that shown

\[40\]

See Figure 3.
in Figure 4), total revenue is given. Find the isocost curve corresponding to the given level of total revenue. The maximum capital intersection of the isocost curve with the isoquant yields a maximum, breakeven amount of capital for that level of output. Repeating for all levels of output yields a capital-output locus representing zero profits (see Figures 5 and 6).

As shown in Figure 5, for \( X > X_3 \), total cost exceeds total revenue, and there is no level of capital on the isoquant such that total cost equals total revenue. For \( X > X_3 \), there is a breakeven level of capital for every \( X \) in the usual case depicted in Figure 3. At low levels of \( X \), the breakeven isocost curve lies close to the minimum cost curve (the difference between total revenue and total cost is small). At \( X_4 \) (in Figure 3), the breakeven isocost curve is a maximum distance from the minimum cost isocost curve (the difference between total revenue and minimum total cost is a maximum), and the distance declines to zero as \( X \) approaches \( X_{\text{max}} \) or \( X_3 \). As a consequence of this capital will tend to increase relative to the minimum cost expansion path, then decrease.

Maximizing utility subject to the breakeven and production constraints yields a solution such as \( X^*, K^* \) shown in Figure 6 or at the endpoint \( X_3 \). If the indifference curves are relatively flat, a low level of output will be produced efficiently. In
extreme cases where \( U = U(K) \) the indifference curves are horizontal and where \( U = U(X) \) the indifference curves are vertical so that these utility functions may be treated as subcases of the more general utility function.

2.2.4 Summary

All of the three behavioral motivations examined in the above sections: recovery of costs, output maximization, and utility maximization, are similar in that they predict that hospitals will breakeven (with an appropriate return to capital included in costs). Evidence on rates of return earned by hospitals, however, indicates wide disparity across geographical areas and over time. Additional theoretical development is required to explain this phenomena.

The recovery of costs model implies that all services will be priced at average cost. Clearly, this is not the behavior found in most hospitals.

The main prediction of the output maximization model is that those prices which most influence whether or not a patient will be hospitalized and how long he will stay are set lower

\footnote{The models could be revised to include a minimum profit constraint. Unlike corporations, the hospital does not have to appease stockholders with a minimum flow of dividends. See Baumol, \textit{op. cit.}, and Williamson, \textit{op. cit.}, for discussions of minimum profit constraint rationale in the case of corporations.}

\footnote{See, for example, Feldstein and Waldman, "Financial Position of Hospitals in Early Medicare Period."}

\footnote{See, for example, McFarland, Hospital and Medical Economics, and Kaitz, \textit{Pricing Policy and Cost Behavior in the Hospital Industry}. More evidence on this point will be presented in Section 4.3 below.}
relative to costs than prices which have no appreciable effect on number of patients which will be hospitalized. Tentative evidence suggests that prices of room services relative to costs do tend to be lower than prices of ancillary services relative to costs. This type of pricing behavior, however, is not inconsistent with the pricing behavior of profit-maximizing hospitals given appropriate differences in elasticity of demand for the two types of services.

The utility maximization model is somewhat unenlightening since virtually any type of behavior may be explained as resulting because it gives utility. As Jorgensen points out:

"The neoclassical theory ... is a far more powerful theory than the 'broader view' utility maximization ... in the sense that a much narrower range of conceivable behavior is consistent with it than the amorphous utility-maximizing theory." 45

A narrower theory of the economic behavior of hospitals which gives more precise predictions and can be empirically tested should be more useful. The next chapter will develop such a theoretical model.

44 See Kaitz, *Pricing Policy and Cost Behavior in the Hospital Industry*.
CHAPTER 3

A Theoretical Model of Output and Investment Determination in Non-Profit, Private Hospitals

3.1 Output and Investment Determination

It will be argued in this chapter that there are many similarities between the way economic decisions are made in non-profit, private hospitals and in profit-maximizing firms. In particular, it will be hypothesized that short-run determination of the pricing of hospital services and of the use of variable inputs is based on the maximization of net patient revenue.¹ Legal and institutional factors, however, will cause investment decisions to diverge from those of a profit-maximizing firm.

The theoretical model of output and investment determination in non-profit, private hospitals proposed here consists of five major hypotheses: 1) demand for an individual hospital's services increases with increases in the hospital's capital stock, 2) short-run costs of producing output also depend upon the level of the hospital's capital stock, 3) prices of services are set so as to maximize short-run net patient revenue, 4) hospitals neither borrow nor accumulate funds; all net patient revenue and

¹ Net patient revenue is defined as the excess of patient revenue over operating expenses. See Section 3.1.2 for more details.
and revenue from external sources are invested in additional plant and equipment, and 5) funds for investment are allocated among projects so as to maximize future net patient revenue.

3.1.1 Demand for a Hospital's Services

The demand for hospital services facing an individual hospital is rather unusual in that it is influenced by the capital stock of the hospital. This stems primarily from the institutional restriction which requires patients to be hospitalized where their doctors are affiliated. The relevant market facing the hospital, therefore, depends upon the number of doctors affiliated with the hospital, the size of their clientele, and the extent to which doctors are affiliated with more than one hospital. Increasing the number of doctors affiliated with the hospital is likely to shift the demand curve for any given period to the right.

As indicated in Section 2.2.3 above, the main way in which a hospital may attract more doctors is by increasing the specialized equipment which it has available. Since doctors may be affiliated with only one or two hospitals, they prefer to be affiliated with fully equipped hospitals which can treat a wide variety of hospitalization cases. Demand for a physician's services is partially derived from his access to specialized

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equipment, giving additional incentive for him to affiliate with well-equipped hospitals. Physicians may also expect that a well-equipped hospital will quickly acquire new equipment.

Besides indirectly increasing the relevant market facing the hospital by increasing the number of doctors affiliated with the hospital, acquisition of capital may have a direct effect upon the relevant market. As the hospital acquires more and more specialized equipment, additional cases will be treated in the hospital which previously might have been treated elsewhere. For example, acquisition of dental surgical equipment will bring in dental surgery patients who might otherwise have been treated in a dental office.

This hypothesis is a variant of the "supply creates its own demand" argument. In this case it is increases in the extensiveness of capital equipment which increase demand rather than increases in number of beds available. To the extent that doctors prefer to be affiliated with bigger, as well as fully equipped, hospitals, increase in bed capacity would increase demand for hospital's services.

In the following analysis, the demand curve will be interpreted as the quantity of hospital services that would be

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3 See p. 12-15 above. In some respects, capital of the hospital acts as does advertising for a firm. As the hospital spends more on capital equipment, its demand increases. As the firm spends more on advertising and selling expenses, its demand increases.
demanded for each price charged by the hospital given levels of income, state of health, and insurance coverage, as well as the hospital's size and extensiveness of capital equipment. Since income and health may appropriately be considered exogenous variables, neglect of their role is inconsequential. Extent of insurance coverage, however, is likely to interact with the general level of hospital charges. As a hospital increases its prices, potential consumers of its services may change their insurance coverage. Short-run quantity demanded at the new higher price may differ from quantity demanded after insurance adjustments are made. No attempt will be made here, however, to develop a theory of demand for insurance or the speed of adjustment to change in hospital charges. Instead the hospital will be assumed to estimate shifts in the demand curve caused by induced changes in insurance coverage and to make its decisions on the basis of quantity which would be demanded at any given price in any given period given adjustments in insurance coverage.

The hospital will be depicted as a multi-product (or multi-service) firm producing such services as semi-private room days, X-rays, laboratory tests, etc., with interdependent demands. For example, an increase in price charged for private rooms may affect demand for semi-private rooms.

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Initially, the major sources of revenue included in the model will be patient revenue resulting from charges made by the hospital and revenue from external sources such as private contributions. In a later section, revenue for services rendered but based upon a contractual agreement will be included. In particular, reimbursement for Medicare and Medicaid beneficiaries will be incorporated into the model since these beneficiaries represent a significant portion of bed-days in hospitals.

It will be assumed that the hospital is a monopolist, not in the sense that there is only one hospital in a given geographical area, but in the sense that changes in one hospital's prices do not substantially affect demand facing other hospitals in the area. If the patient has a choice among several hospitals, the selection is made on a non-price basis. This assumption is made primarily to simplify the analysis by neglecting interactions among hospitals. In this way attention can be focused on a hospital's rate structure and investment behavior.

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Reder, for example, states, "I venture the guess that demand for beds in a given hospital is independent of their prices relative to other hospitals in the same area." "Some Problems in the Economics of Hospitals," p. 477. Weisbrod also emphasizes that "competition is constrained by financial and other barriers to entry and by institutional arrangements which limit access by a patient to the one or more hospitals with which his physician is associated." "Some Problems of Pricing and Resource Allocation in a Non-Profit Industry: The Hospitals," p. 18.
3.1.2 Short-Run Costs

For the purposes of this analysis short-run costs will be defined as all operating expenses. Since the institutions under consideration are tax-exempt, this definition would not include tax payments. Depreciation on capital would not be counted as a short-run cost although maintenance and repair expenditures would. Economic return to capital would also not be classified as a short-run cost. Short-run costs are defined in this way so that gross patient revenue less short-run costs will be equal to net patient revenue. Net patient revenue, then, will constitute the increment to the pool of internal funds available for new investment.

Short-run costs will depend upon the level of capital stock for four major reasons. First, certain items included in short-run costs may be expected to vary directly with size of plant and extensiveness of capital equipment (for example, maintenance). Second, if acquisition of new types of capital permits the production of new types of services, total short-run costs will increase. Production of additional services will require acquisition of non-capital factor inputs. For example, if the hospital acquires cobalt therapy facilities and begins to provide cobalt therapy treatments, new personnel (including perhaps a nuclear physicist) will be employed so that the total costs of the hospital's operations will increase. Third,
an increase in capital may substitute for other factors of production so that short-run costs are lowered. In economic terms, an increase in capital may shift the marginal physical productivity of labor curve upward and the marginal cost of output curve down. Fourth, increased scale of operations may permit economies of production so that short-run costs change.

Since additions to capital stock may be expected to increase some short-run costs and decrease others, the net effect must be empirically determined.

3.1.3 Pricing of Hospital Services

It is hypothesized that hospitals set prices so as to maximize net patient revenue (gross patient revenue less short-run costs). Short-run costs, as defined above, exclude some capital costs, but marginal costs in the short run are unaffected as long as the excluded capital costs (depreciation, for example) do not vary with output. Maximization of net patient revenue, therefore, is equivalent to short-run profit maximization.

It is possible that the hospital may be constrained in its net patient revenue maximization by various social or political factors. A maximum limit on various prices may be set to avoid such unpleasantries as 1) public outcry at excessive charges, 2) repercussions from powerful organizations such as Blue Cross
or governmental agencies from prices that are "too far out of line," or 3) aggressive price competition from other hospitals. The importance of the first cause is limited by the poor information available to the public. Net patient revenue data are rarely published, and as will be pointed out later all net patient revenue is invested so that hospitals typically do not have large sums of liquid assets. Complaints of excessive charges from powerful agencies may be countered with difficult-to-refute arguments regarding the superior quality of care rendered. Since patients have poor information about variations in hospital charges among hospitals and little choice regarding selection of hospital, the third type of constraint mentioned above is unlikely to be substantially significant.

The formal model will not embody these constraints, but in cases where they are deemed to be important they may easily be incorporated in the form of maximum ceilings on various prices (or equivalently, minimum levels of output).

3.1.4 Internal Funds and Investment

Non-profit organizations are legally restricted from distributing dividends. All net patient revenue accruing to the organization, therefore, must be retained. The hospital does have some choice, however, regarding the disposition of the funds generated internally. It could use the surplus to
reduce prices and subsidize losses in future periods. Alternatively, it could loan the money, invest it in external projects such as real estate, stocks, bonds, etc., or simply keep the funds in the form of very liquid assets. The principal drawback to making loans or financial investments is the possibility of these transactions becoming public knowledge with resulting unfavorable public opinion.

The most obvious method of disposing of the available funds is simply to use them to make additions to the hospital's plant and equipment. This disposition of the funds can be justified to the public as necessary to increase the range of services or quality of care rendered. In view of the much publicized shortage of hospital facilities (in spite of a national occupancy rate of only 78.5 percent of capacity\(^6\), hospital administrators can argue that prices must be set at levels yielding surplus funds so that the "need" for hospital care can be met by increasing the hospital's capacity to serve patients. Public reaction is, therefore, minimized.

On the other hand, hospitals have traditionally been reluctant to borrow funds for investment in plant and equipment. Whether this stems from a rational calculation that borrowing

would merely reduce private contributions by an equal amount is unclear.

It is the hypothesis of this paper that hospitals neither borrow to any significant extent nor accumulate liquid or financial assets. All net patient revenue is invested in plant and equipment. Unearmarked private donations are also used to increase plant and equipment. In the model a simple lag adjustment of one period is assumed. The proper lag adjustment is largely an empirical question and will not be treated here.

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7 Klarman reports that the role of private contributors in financing hospital construction has been declining in relative importance. Philanthropic income as a percentage of total hospital income has declined from 13.7 percent in 1935 to 6.1 percent in 1950 to 4.2 percent in 1958. The proportion of total construction expenditures met by philanthropy was 19.5 percent in 1959. Klarman also finds that there has been an increasing tendency for philanthropic funds to be earmarked for specific uses. Most philanthropic income is devoted to free care. Herbert E. Klarman, "The Role of Philanthropy in Hospitals," American Journal of Public Health, LII (August, 1962), p. 1227–37.


3.1.5 Composition of Investment

Given that the hospital has a fixed sum which must be invested in any given period, it is still necessary to explain the allocation of these funds among alternative projects. It is hypothesized that the fixed amount of investment funds is allocated so as to maximize future net patient revenue. For simplicity, it is assumed that estimates of future net patient revenue are based on a finite period (usually fairly short).

Two of the possible ways in which investment could increase future net patient revenue have been noted above: 1) by increasing facilities and thus revenue and 2) by decreasing short-run costs. In addition, if output of various profitable services is constrained by existing facilities, addition of these types of capital will permit the hospital to increase the levels of output of these services. This is illustrated in Figure 7. If the capacity constraint is binding, then the short-run marginal cost curve is vertical, and the marginal revenue curve intersects the short-run

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marginal cost curve on the vertical segment. Increasing capacity shifts the vertical section of the short-run marginal cost curve outward. Quantity of services provided increases until the capacity constraint is no longer binding. For example, in Figure 7 as capital increases from $K_1$ to $K_2$, the short-run marginal cost curve shifts from $SRMC_1$ to $SRMC_2$ and output increases from $q_1$ to $q_2$.

Investment priority, therefore, will go to one or more of the following:

1) Capital which will enhance future demand,
2) Capital which will reduce short-run costs,
3) Capital which is currently constraining output.

If the hospital is operating close to bed capacity or demand is growing rapidly, then it should be primarily interested in adding beds. Investment in specialized equipment at this time would not be extremely desirable since its effect would be to increase the number of people desiring admission.

If the hospital is operating at low levels of capacity or demand is stagnant and economies of scale have been exhausted, additional beds would not increase future net patient revenue. In this case investment priority would be likely to go to specialized equipment which would attract more doctors and more patients. If labor costs are rising rapidly, the hospital will be primarily interested in labor-saving types of investment.
Since all net patient revenue and external funds must be
invested, it should be noted that the hospital may even invest
in projects which will reduce future net patient revenue. Priority,
of course, would go to projects which would reduce future net
patient revenue least. For example, a hospital facing slack demand
might acquire cobalt therapy facilities which might foster a new
demand but which would increase short-run costs even more than
the increased revenue because of the high cost of specialized
personnel.

In the formal model, it will be assumed that in each period
the hospital determines amounts and types of investment to be
undertaken only in the given period. Optimal investment in
future periods is not determined. It is possible, however,
that hospitals consider the possibility that investment now
may yield such high future net patient revenue that the hospital
would be forced in the future to undertake negative return
investment in order to avoid accumulating funds.

3.2 Mathematical Statement of the Model

To gain a more precise understanding of the model, it will
now be presented in a nonlinear programming format. This format
was selected because greater detail could be added without
sacrificing clarity. The model is presented in two stages: the
first stage determines the prices of services (or equivalently levels of output) and the second stage determines the allocation of investment funds.

Let 
\[ p_1 = \text{price charged for private room} \]
\[ p_2 = \text{price charged for semi-private room} \]
\[ p_3 = \text{price charged for ward room} \]
\[ p_4, \ldots, p_n = \text{prices charged for ancillary services} \]
\[ p = (p_1, \ldots, p_n) \]
\[ x_1 = \text{quantity of private room days provided} \]
\[ x_2 = \text{quantity of semi-private room days provided} \]
\[ x_3 = \text{quantity of ward room days provided} \]
\[ x_4, \ldots, x_n = \text{quantities of various ancillary services} \]
\[ x = (x_1, \ldots, x_n) \]
\[ K_1 = \text{capital used in provision of private room days} \]
\[ K_2 = \text{capital used in provision of semi-private room days} \]
\[ K_3 = \text{capital used in provision of ward room days} \]
\[ K_4, \ldots, K_n = \text{capital used in provision of various ancillary services} \]
\[ K = (K_1, \ldots, K_n) \]
\[ I_1 = \text{investment in } i\text{th type of capital, } i=1,\ldots,n \]
\[ I = (I_1, \ldots, I_n) \]
\[ s_i = \text{price of investment good } i, i=1,\ldots,n \]
\[ \Gamma = \text{net patient revenue} (* \text{signifies optimal value}) \]
C(x) = short-run costs of providing all services
B = revenue from external sources (such as benefactors)
d = hospital's time discount rate\(^{11}\)
\(\delta_i\) = rate of depreciation on ith capital good, i=1,...,n
\(t\) = subscript indicating time period, \(t=0\) is initial time period

Bar above variable indicates variable is fixed during analysis.

Stage 1: Determination of Levels of Output of Hospital Services

maximize \[ F_o = p_{1o}(x_{1o}, \bar{K}_o)x_{1o} + \ldots + p_{no}(x_{no}, \bar{K}_o)x_{no} - C(x_o, \bar{K}_o) \]
subject to \[ x_{1o} \leq \bar{K}_{1o} \]
\[ \vdots \]
\[ x_{no} \leq \bar{K}_{no} \]
and \[ x_o \geq 0 \]

Stage 2: Allocation of Investment Funds

maximize \[ F = \sum_{t} d_t \left[ p_{1t}(x_{1t} \bar{K}_o + I_1)x_{1t} + \ldots + p_{nt}(x_{nt} \bar{K}_o + I_n)x_{nt} - C_t(x_t, \bar{K}_o + I_1) \right] \]
subject to \[ x_{1t} \leq (1-\delta_1)\bar{K}_{1o} + I_{1t} \quad t=1,...,T \]
\[ \vdots \]
\[ x_{nt} \leq (1-\delta_n)\bar{K}_{no} + I_{nt} \]
\[ s_{1l}I_{1l} + \ldots + s_{nl}I_{nl} = F_0 + B_o \]
\[ x_t, I_1 \geq 0 \]

3.3 Interpretation of the Model

The first stage is the standard short-run profit maximization model (with a slightly different definition of total costs). The constraints indicate the limits to output represented by the fixed amount of capital. These appear in a very simple form, but may be replaced by functions of x less than or equal to K if desired. As presented, they imply a one-to-one relationship between various outputs and various types of capital. This embodies the assumption that the flow of capital services is proportional to the capital stock so that K may represent either a stock or a flow (e.g. 200 beds or 200x365 bed-days per year). It should be noted that $K_{it}$ may initially be zero. For example, if $x_{it}$ is cobalt therapy treatments and no cobalt therapy facilities are available, then $x_{it} \cdot K_{it} = 0$ implies that $x_{it} = 0$ (no cobalt therapy treatments are provided).

The second stage determines the levels of investment in various types of capital to be undertaken in the current period. The objective function to be maximized is future net patient revenue in the next T periods. Investment enters the objective function both as it affects future demand and as it affects future short-run costs. Investment also relieves the constraints on output. The final constraint requires that the total investment be exactly equal to last period's net patient revenue plus any external funds.
In a somewhat similar model, Weingartner has shown that if the firm can borrow and lend at the given market interest rate, the capital budgeting solution is exactly equivalent to maximizing the present value of the firm using the market interest rate as the discount rate. The essential difference here, therefore, is the requirement that all internal funds be spent on plant and equipment and borrowing does not occur.

If costs are rising faster than demand is growing, $F_o^*$ may tend to decline. Even though profitable investment projects may be available (i.e. projects whose present discounted value exceeds cost), the hospital would not have sufficient internal funds to undertake the projects. For example, if economies of scale in the provision of services exist, small hospitals would not have sufficient funds to expand and exploit these economies. If costs continue to rise $F_o^*$ may be driven to negative levels and the hospital will go bankrupt unless private donations make up the difference.

The extreme opposite case could also occur. If demand is growing rapidly (because of increases in population, income, etc.), $F_o^*$ may increase over time. Eventually, all profitable investments may be undertaken. Using internal funds to undertake additional investment in plant and equipment may yield a lower return than the hospital could obtain by lending. Since the hospital is constrained to spend all funds on plant and equipment, the hospital may even undertake projects which decrease future net patient revenue.

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Weingartner, Ch. 8.
3.4 Medicare

The model presented above is based upon the assumption that all consumers of hospital services pay the price charged by the hospital (either directly or indirectly through insurance). In some cases, however, hospitals make contractual agreements under which certain groups of patients do not pay the charges levied by the hospital. Hospitals are reimbursed for services rendered to these patients on the basis of a separate agreement. For example, in some states hospitals are reimbursed for the care of Blue Cross patients not according to the charges levied by the hospital but according to per diem cost of caring for all patients.\textsuperscript{13}

Enactment of Medicare legislation represents an important switch from private paying patients to contractually covered patients. Given the hypotheses regarding hospital behavior developed above, it is possible to derive predictions regarding the impact of the implementation of Medicare on prices charged private patients and on hospital net patient revenue. To this end, Section 3.4.1 briefly describes Medicare reimbursement formulae. Section 3.4.2 then analyzes the impact of Medicare on prices charged private patients and net patient revenue accruing to hospital under the simplifying assumption that the

\textsuperscript{13} See Blue Cross Association, "Hospital Reimbursement Methods of Blue Cross Plans," in Third-Party Reimbursement for Hospitals (Bloomington, Ind.: Indiana University, 1965).
hospital only produces one service. Section 3.4.3 examines the differential impact of Medicare on the entire rate structure of the hospital, and Section 3.4.4 treats the differential impact of Medicare on the net patient revenue accruing to different sized hospitals.

3.4.1 The Medicare Reimbursement Formulae

The methods devised to reimburse hospitals for the care of Medicare patients attempt to reflect the actual average cost of services received by Medicare patients. The simplest scheme (used by Blue Cross) of paying hospitals the average cost of all patient-days times the number of Medicare beneficiary patient-days was rejected on the grounds that older patients tend to consume different quantities of hospital services than younger patients. Accordingly, it was decided to separate reimbursement for ancillary services from reimbursement for routine services. Hospitals are given a choice between the departmental method of reimbursement and the combination method of reimbursement.  

Under the departmental method, all hospital costs are allocated to various departments (such as routine services, X-rays, laboratory). Medicare patients are billed for each type of service

14 See, for example, Somers and Somers, Medicare and the Hospitals.

consumed on the same basis as private patients. Actual reimbursement to the hospital, however, is the ratio of Medicare charges to total patient charges for the services of each department applied to the cost of the department. That is,

\[
\text{Reimbursement} = \frac{\sum_{i=1}^{M} p_{ji} q_{ji}}{\sum_{i=1}^{M} p_{ji} q_{ji}^T} C_1 + \ldots + \frac{\sum_{i=1}^{M} p_{ni} q_{ni}}{\sum_{i=1}^{M} p_{ni} q_{ni}^T} C_n
\]

where \(C_j\) is total cost of \(j\)th department, \(p_{ji}\) is price of \(i\)th service in \(j\)th department, \(q_{ji}\) is quantity of \(i\)th service in \(j\)th department received by Medicare beneficiaries, \(q_{ji}^T\) is quantity of \(i\)th service in \(j\)th department received by all patients.

Under the combination method, the cost of routine services for Medicare beneficiaries is average cost per diem of these services for all patients. Reimbursement for ancillary services received by Medicare beneficiaries is determined by applying the ratio of beneficiary charges for ancillary services to total patient charges for such services to total cost of ancillary services. That is,

\[
\text{Reimbursement} = \frac{C_R}{q_R} \frac{\sum_{i=1}^{M} p_{i} q_{i}^T}{\sum_{i=1}^{M} p_{i} q_{i}^T} + \frac{\sum_{i=1}^{M} p_{i} q_{i}^T}{\sum_{i=1}^{M} p_{i} q_{i}^T} C_A
\]

where \(C_R\) is total cost of routine services, \(C_A\) is total cost of \(M\) ancillary services, \(q_R\) is Medicare patient-days, \(q_R^T\) is total \(M\) patient-days, \(p_i\) is price of \(i\)th ancillary service, \(q_i^T\) is quantity of \(i\)th ancillary service received by Medicare patients, \(q_i^T\) and \(q_i\) is quantity of \(i\)th ancillary service received by all patients.
In addition, non-profit hospitals are granted an allowance of two percent of costs "in lieu of specific recognition of other costs in providing and improving services."\textsuperscript{16} Total reimbursement is then $1.02$ times amounts shown above.

3.4.2 Impact of Medicare on Charges to Private Patients and on Hospital Net Patient Revenue

In order to simplify the analysis of the impact of Medicare on prices charged private patients, it will be assumed initially that hospitals produce only one service. Both Medicare reimbursement formulae then reduce to average cost of care for all patients times number of Medicare patients, i.e. Reimbursement $= q \frac{M \bar{C}}{qT}.$

There is some evidence that prior to Medicare, hospitals tended to price discriminate in favor of older or lower-income patients.\textsuperscript{17} Analysis of the impact of Medicare, therefore, is based upon a third-degree price discrimination model with two markets, one composed of persons over age 65 and the other composed of all persons under age 65.\textsuperscript{18}

Let NR be net patient revenue, $Y$ be quantity of hospital services received by younger patients, $M$ be quantity of hospital services received by older patients, $P(Y)$ be demand in younger


\textsuperscript{17} See, for example, Somers and Somers, Medicare and the Hospitals, p. 154.

\textsuperscript{18} For more information on the price discrimination model, see Joan Robinson, The Economics of Imperfect Competition (London: Macmillan Co., 1933), Ch. 15.
market, \( P(M) \) be demand in older market, \( Q = Y + M \), \( VC \) be total variable costs, \( MR \) be marginal revenue, \( MC \) be marginal costs, \( TC \) be total costs, and \( AC \) be average costs.

Under the hypothesis that hospitals set prices so as to maximize net patient revenue, marginal revenue in each market before Medicare is equal to marginal cost of total output:

Maximize \( NR = P(Y) Y + P(M) M - VC(Y+M) \)

1) \( \frac{\Delta NR}{\Delta Y} = MR_y - MC_Q = 0 \)
2) \( \frac{\Delta NR}{\Delta M} = MR_m - MC_Q = 0 \)
3) Thus, \( MR_y = MR_m = MC_Q \)

Graphical illustration of prices and net patient revenue before Medicare is given in Figure 8 (marginal cost is assumed constant). Price of hospital services to young is \( OC \), quantity of services received by young is \( OA \), price to elderly is \( OT \), quantity received by elderly is \( OR \), and total net patient revenue is area \( BCDE \) + area \( STUV \).

Implementation of Medicare has the effect of reducing price charged elderly to zero so that quantity \( O\hat{W}' \) is demanded (see Figure 9). If the hospital provides quantity \( O\hat{W}' \) services to elderly, it is reimbursed by the average cost of caring for

\[ 19 \]

The deductible provision of Medicare is neglected here.
FIGURE 8

Aggregate

\( OW = OD = OU \)
\( OQ_o = OA + OR \)

Young

Elderly

MC = AVC

MR_Y

D_Y

MR_M

D_M

$
FIGURE 9

Aggregate

$\text{AC}(1.02)$

$O_W = O_W'$

$P_Q = P'Q'$

$K_L = K'L'$

$W_Z = O_A'$
all patients times quantity \(Q^{'}\). Determination of quantity of services to provide young patients, therefore, involves two considerations: the direct effect of quantity on revenue from young market and the indirect effect of quantity on average cost of caring for all patients (hence on Medicare reimbursement for elderly patients). Formally, the hospital seeks to set price in young market so as to maximize net patient revenue where net patient revenue equals revenue from young market plus Medicare reimbursement less variable costs.\(^{20}\)

\[
\begin{align*}
\text{Maximize } & \quad NR = P(Y) Y + \frac{\overline{M}}{Y+\overline{M}} \left( \frac{TC(Y+\overline{M})}{Y+\overline{M}} - VC(Y+\overline{M}) \right) \\
1) & \quad \frac{dNR}{dY} = MR_Y + \overline{M} \left( \frac{MC_Q - AC_Q}{Y + \overline{M}} \right) - MC_Q = 0 \\
2) & \quad \text{Thus, } MR_Y = \frac{\overline{M}}{Y+\overline{M}} (AC_Q - MC_Q) = MC_Q \\
\text{Let } & \quad MR_Y^* = MR_Y - \frac{\overline{M}}{Y+\overline{M}} (AC_Q - MC_Q).
\end{align*}
\]

If average costs are constant for all \(Q\), then \(MR_Y^* = MR_Y = MC_Q\).

If average costs are decreasing over the relevant range, however, \(MR_Y > MC_Q\), i.e. the hospital curtails output of services to young market to avoid reducing average cost of caring for all patients as much as it would if it set marginal revenue in young market equal to marginal cost.

Graphical illustration of prices and quantities provided after the implementation of Medicare are shown in Figure 9. Output

\(^{20}\) Variable costs are assumed to be the same as short-run costs defined in Section 3.1.2 above.
of services provided young market is determined by setting
\[ MR^*_Y = MC_Q. \]
Since \( MR^*_Y = MR_Y = (AC_Q - MC_Q)\bar{m}/(Y + \bar{m}) \), \( MR^*_Y < MR_Y \) if average cost is decreasing. Output of services provided to young market is, therefore, less than it was before Medicare (or equivalently, prices charged young patients are higher after Medicare). As shown in Figure 9, price charged young patients is \( OC' \) and quantity of services provided is \( OA' \). Medicare reimbursement is determined by 1.02 times the average cost of caring for all patients, or \( ZQ \) as shown in Figure 9. Net patient revenue is then area \( B'C'D'E' \) plus \( OW'T'.P'Q' \). Net patient revenue will be greater after Medicare if Medicare reimbursement exceeds net patient revenue received in elderly market prior to Medicare. That is, net patient revenue will increase with Medicare if \( OW' \cdot P'Q' \) in Figure 9 exceeds area \( STUV \) in Figure 8 (by an amount greater than the slight reduction in net patient revenue in young market). This would be probable, for example, if price charged elderly prior to Medicare covered average variable costs but not average total costs.

In summary, Medicare would have the effect of raising prices charged non-Medicare patients if short-run average costs are falling throughout the relevant range (a fairly reasonable assumption given the high fixed costs of providing hospital care). Net patient revenue would be increased if prices charged elderly were relatively

\[ 21 \]

The analysis assumes that the capacity constraint is not binding. If increased services to Medicare patients causes the capacity constraint to bind (in the sense of Figure 7 above), prices charged non-Medicare patients will be higher.
low prior to Medicare. Change in net patient revenue, however, would have to be determined on a case by case basis given demand for hospital services by elderly facing a given hospital and the hospital's short-run cost curve.

3.4.3 Impact of Medicare Upon Rate Structure

In the above section the hospital was assumed to produce only one good so that the Medicare reimbursement formulae reduced to average cost per patient day. In practice, however, hospitals produce many separately priced services. Since the reimbursement formulae include these various prices, incentives for changing the internal rate structure are created by the implementation of Medicare.

In order to focus upon the internal rate structure, the indirect effects of changes in prices of services charged young after Medicare on average cost (by changing total quantity provided) will be neglected. It will be assumed that immediately after the implementation of Medicare, prices charged the young are at maximum net patient revenue levels in absence of Medicare. Then, it will be determined under what conditions slight changes in pre-Medicare prices will lead to greater reimbursement under Medicare.

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22 For example, Kaitz notes, "most hospital administrators view Medicare and Medicaid as a financial windfall." Pricing Policy and Cost Behavior in the Hospital Industry, p. 49.
As described in Section 3.4.1, reimbursement under the departmental method is as follows:

\[
\text{Reimbursement} = \frac{\sum_{i=1}^{M} \bar{P}_{i}q_{i}}{\sum_{i=1}^{M} \bar{P}_{i}q_{i}^{T}} C_{1} + \ldots + \frac{\sum_{i=1}^{M} \bar{P}_{i}q_{i}}{\sum_{i=1}^{M} \bar{P}_{i}q_{i}^{T}} C_{n}
\]

Changing price of given service, then, changes amount of Medicare reimbursement as follows:

\[
\frac{\partial \text{GR}}{\partial P_{jk}} = C_{j} \left[ \frac{M}{q_{jk}} \sum_{i=1}^{M} \bar{P}_{i}q_{ji}^{T} - q_{jk}^{T} \sum_{i=1}^{M} \bar{P}_{i}q_{ji} \right]
\]

\[
= C_{j} \frac{q_{jk}^{M} - q_{jk}^{T} ( \sum_{i=1}^{M} \bar{P}_{i}q_{ji}^{T} / \sum_{i=1}^{M} \bar{P}_{i}q_{ji} )}{\sum_{i=1}^{M} \bar{P}_{i}q_{ji}}
\]

Government reimbursement will increase with a change in the price of the kth service in the jth department if:

\[
\frac{\partial \text{GR}}{\partial P_{jk}} > 0 \iff q_{jk}^{M} > q_{jk}^{T} \left( \sum_{i=1}^{M} \bar{P}_{i}q_{ji}^{T} / \sum_{i=1}^{M} \bar{P}_{i}q_{ji} \right)
\]

\[
\iff \frac{q_{jk}}{q_{jk}^{T}} > \frac{\sum_{i=1}^{M} \bar{P}_{i}q_{ji}}{\sum_{i=1}^{M} \bar{P}_{i}q_{ji}^{T}}
\]

\[
\iff \frac{p_{jk}q_{jk}^{M}}{p_{jk}q_{jk}} > \frac{\sum_{i=1}^{M} \bar{P}_{i}q_{ji}^{M}}{\sum_{i=1}^{M} \bar{P}_{i}q_{ji}^{T}}
\]

Medicare reimbursement will increase with an increase in the price of a service if the quantity of that service received by Medicare patients relative to the quantity of that service received by all
patients is greater than the ratio of all services in that
department received by Medicare patients to total services provided
in that department (where quantities of services within department
are weighted by prices).

For example, if Medicare patients receive 40 percent of
hip X-rays provided by the X-ray department in a given period
but only 30 percent of all X-rays provided by the department during
the period, then increasing the price of hip X-rays will increase
Medicare reimbursement.

Increases in prices of services used relatively more
intensively by Medicare patients will increase Medicare reimburse-
ment at a diminishing rate as shown below:

\[ \frac{\partial^2 \text{GR}}{\partial p_{jk}^2} = -\frac{2 a_{jk}^T (\frac{M}{q_{jk}} - q_{jk} \frac{p_{ji} q_{ji}^M}{p_{ji} q_{ji}^T})}{(\sum p_{ji} q_{ji}^T)^2} \]

Therefore, \( \frac{\partial^2 \text{GR}}{\partial p_{jk}^2} < 0 \) if \( \frac{M}{q_{jk}} > \frac{p_{ji} q_{ji}^M}{p_{ji} q_{ji}^T} \)

The gains in reimbursement from Medicare, however, may be
partially offset by reduction in profits in non-Medicare market.
Since prices are initially at maximum net patient revenue levels
before Medicare, increasing the price of a given service will
reduce the quantity of that service demanded by non-Medicare
patients and consequently reduce net patient revenue in non-
Medicare market. Diminishing increases in Medicare reimbursement with increases in prices of services used relatively more intensively by Medicare patients and reductions in net patient revenue in non-Medicare market will then limit the extent to which it is desirable to increase prices of services used relatively more intensively by Medicare patients.

Similarly, decreasing prices of services used relatively less intensively by Medicare patients will increase Medicare reimbursement. Also, desirable reduction in prices of these services is limited by subsequent reduction of net patient revenue in non-Medicare market.

If the hospital elects to use the combination method of reimbursement, many of the same incentives for differential price changes occur. As described in Section 3.4.1, reimbursement under the combination method is as follows:

\[ \text{Reimbursement} = \frac{M}{q_R} C_A + \frac{\sum_i p_i q_i}{\sum_i p_i q_i} C_A \]

Changing price of given ancillary service changes amount of Medicare reimbursement as follows:

\[ \frac{\partial \text{GR}}{\partial p_k} = \frac{M}{q_k} - q_k \left( \frac{\sum_i p_i q_i / \sum_i p_i q_i}{\sum_i p_i q_i} \right) \]

so that

\[ \frac{\partial \text{GR}}{\partial p_k} > 0 \iff \frac{q_k}{q_k} > \frac{\sum_i p_i q_i}{\sum_i p_i q_i} \]
This differs from the departmental method in two ways: 1) it is not possible to increase Medicare reimbursement by making differential changes in prices of routine services since routine services are reimbursed on basis of average cost per patient-day and 2) Medicare reimbursement can be increased by increasing prices of services used more intensively by Medicare patients relative to all ancillary services provided by the hospital, rather than relative to all services provided by the department.

For example, if Medicare patients represent 30 percent of all hospital ancillary services but only 0 percent of delivery room services, Medicare reimbursement can be increased by reducing price of delivery room services. Or suppose Medicare patients receive 35 percent of a certain blood test and Medicare patients also receive 35 percent of all laboratory tests. Then under the combination method, Medicare reimbursement will be increased by increasing the price of the specific blood test (since Medicare patients represent 35 percent of this test which is greater than the 30 percent of all hospital ancillary services which they receive). Under the departmental method, however, increasing the price of the specific blood test would have no effect on Medicare reimbursement (since Medicare patients receive 35 percent of the specific blood test as well as of all laboratory departmental services).
In summary, the particular formulae devised for reimbursing hospitals for the care of Medicare patients create incentives for the hospital to change its internal rate structure. In particular, prices of services which are used relatively more intensively by Medicare patients will tend to rise while prices of services which are used relatively less intensively by Medicare patients may fall. The possibility of increasing reimbursement from government by making differential changes does not seem to have escaped hospital officials. As Somers and Somers quote Steven Sievers, Associate Executive Director, Hospital Planning Association of Allegheny County:

"If Medicare's reimbursement is based on the proportion of a department's charges incurred by old people, it is a simple matter to raise charges selectively in order to raise reimbursement. I heard an administrator say: 'RCC [ratio of Medicare beneficiary charges to total patient charges] is based on certain hospital statistics but the key statistic is controllable by the hospital.' It is easy and defensible to inflate the prices on services rendered mainly to old people."23

3.4.4 Relationship of Medicare Reimbursement to Hospital Size

Since Medicare reimbursement is based upon average total costs of caring for patients, hospitals with different capital intensities will have different amounts of reimbursement even

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23 Somers and Somers, Medicare and the Hospitals, p. 169.
if they care for the same number of patients. According to
the theoretical model of hospital behavior developed above, all
net patient revenue which hospitals receive is invested. If
larger hospitals have higher reimbursements, investment in larger
hospitals will increase relative to smaller hospitals.

That Medicare does provide more net patient revenue for
hospitals with higher capital intensity can be seen quite simply
in Figure 10. Suppose that two hospitals have the same demand
conditions (both in young and elderly markets). Assume that
hospital one has higher variable costs per unit of output than
hospital two but lower average fixed costs per unit of output,
i.e. hospital one employs fewer fixed resources (such as capital)
relative to its variable resources than hospital two in providing
the same quantities of service.

If hospital one maximizes its net patient revenue after the
implementation of Medicare, it will be providing quantity OA in
the young market and quantity OW in the elderly market (see Figure
9 or Figure 10). Hospital one's net patient revenue is area $\text{BCDE}$
plus area $\text{OWFP}$. For purposes of comparing hospital two's net
patient revenue with hospital one, assume that hospital two
provides the same quantities of service as hospital one. This will
not necessarily correspond to the maximum net patient revenue
position of hospital two. If hospital two does provide the same
quantity of service as hospital one, hospital two's net patient
revenue is area $\triangle BCFG$ plus area $\triangle OW\cdot RS$. Since hospital two has more fixed costs, $RS > PQ$ and $\triangle OW\cdot RS > \triangle OW\cdot PQ$. Clearly, area $\triangle BCFG$ is greater than area $\triangle BCDE$. Therefore, hospital two receives greater net patient revenue than hospital one even if it provides the quantity of service which maximizes hospital one's net patient revenue. If it provides that quantity of service which maximizes its own net patient revenue, it could be expected to make even more net patient revenue than hospital one.

If comparison is made between hospitals providing different quantities of services to elderly but same average cost of caring for all patients, Medicare reimbursement per Medicare beneficiary day will be the same, but total quantity of Medicare reimbursement will be greater for hospitals serving more patients.

In summary, for hospitals with the same size markets but differing capital intensities, those hospitals with greater capital intensity will receive greater amounts of net patient revenue. Larger hospitals serving larger markets will also have more net patient revenue available for additional investment than smaller hospitals.
CHAPTER 4

Empirical Evidence

In this chapter, available information on hospital behavior will be examined to see if it corroborates the five major hypotheses postulated in the theoretical model: 1) demand for a hospital's services increases with increases in the hospital's capital stock, 2) short-run costs of producing output also depend upon the level of the hospital's capital stock, 3) prices of services are set so as to maximize net patient revenue, 4) hospitals neither borrow nor accumulate funds to any significant extent so that all net patient revenue and revenue from external sources are invested, and 5) investment funds are allocated among projects so as to maximize future net patient revenue. In addition a simultaneous equation model of output and factor input determination is estimated.

Empirical work on hospital behavior is handicapped by the scarcity of available data. Price and quantity data on ancillary services are lacking. Detailed components of cost are unavailable. Information on the composition of capital stock held by a hospital is scarce. The following sections will develop relevant empirical models for testing each of the hypotheses and then discuss modifications of the models necessitated by incomplete data.
4.1 Effect of Specialized Facilities on Demand for Hospital Services

4.1.1 Empirical Model

It has been hypothesized that a hospital may increase the relevant market facing it by acquiring additional specialized facilities. Since patients must be hospitalized where their doctors are affiliated, hospitals which desire an increase in demand may acquire specialized facilities in an effort to attract doctors. This may take the form of luring new doctors in the profession to a given hospital or existing doctors away from other hospitals in the area. Hospitals acquiring such facilities should experience an increase in market share while those which do not add the facilities should experience a decline in market share.

If a hospital is operating at capacity, increasing the size of the hospital will allow the hospital to serve a larger number of patients. Hospitals expanding the number of available beds, therefore, may also be expected to increase their market share.

It is possible that doctors entering the profession may be attracted to larger hospitals even if both the larger and smaller hospitals have the same specialized facilities. To test for the possible significance of this factor, the number of beds in hospital is included in the model.
The empirical model proposed to examine the relationship between additional capital and market share is as follows:

\[ \Delta MS = a + \sum_{i} b_i F_{i} + cB_{-1} + d \Delta B/B_{-1} + eE + u \]

where \( \Delta MS \) is change in market share, \( F_i \) is \( i \)th specialized facility acquired over the period (1 = acquired, 0 = otherwise), \( B_{-1} \) is bed capacity at end of previous period, \( \Delta B \) is change in bed capacity over period, \( E \) is exogenous changes in demand facing hospital, and \( u \) is a random error term.

4.1.2 Data

Data on individual hospital's bed capacity, number of patient days, and certain specialized facilities are available from the American Hospital Association.\(^1\) Data on 346 short-term private hospitals in 21 major metropolitan areas for the years 1963 and 1966 were collected. This sample represents all hospitals in those areas for which complete data were available.

Market share was defined as the percent of a metropolitan area's patient days provided by a hospital, i.e. \( MS_{im} = PD_{im}/PD_{m} \) where \( MS_{im} \) is market share of \( i \)th hospital in \( m \)th metropolitan area, \( PD_{im} \) is patient days for given year of \( i \)th hospital in \( m \)th metropolitan area, and \( PD_{m} \) is total patient days for all short-term, private hospitals in \( m \)th metropolitan area.

\(^1\) American Hospital Association, *Hospitals, Guide Issue*, XXXVIII (August 1, 1964) and XLI (August 1, 1967).
Facilities for which data were available included: dental surgical facilities, physical therapy facilities, psychiatric facilities, radioisotope therapy facilities, and cobalt–radium therapy facilities. Affiliation with a medical school was also included since this might serve to attract doctors to a given hospital.

Facilities which permit hospitals to care for additional types of cases such as artificial kidney equipment, heart–lung machines for open–heart surgery would have been desirable to include but necessary information was not available.

No attempt was made to account for exogenous changes in demand facing a hospital. For example, changes in the distribution of income within a city might alter the average income of individuals in a given hospital’s market (i.e. patients of doctors affiliated with the hospital). Similarly, differential changes in insurance coverage, age composition, etc. might alter a hospital’s market share.

4.1.3 Results

An ordinary least–squares regression estimation of the model yielded the following:

\[
\begin{align*}
MS &= .002 + .0034 M - .0001 D + .0015 PT + .006 Psy \\
&\quad \left[1.18\right] \left[-.02\right] \left[5.50\right] \left[1.61\right] \\
&\quad - .006 RI - .0002 C - .000005 B + .021 \Delta B/B_{-1} \\
&\quad \left[-.20\right] \left[-.09\right] \left[-1.56\right] \left[5.56\right]
\end{align*}
\]

\[ R^2 = .11 \] t-scores shown in brackets below coefficient estimates.

In the equation, M denotes affiliation with medical school, D indicates possession of dental surgical facility, PT physical therapy facility, Psy psychiatric facility, RI radioisotope facility, C cobalt–radium therapy facility, MS market share, B_{-1} bed capacity at beginning of period.

A positive rate of change of bed capacity significantly increases a hospital's market share at the .01 level. Only acquisition of psychiatric facilities is found to affect significantly market share at about the .10 level. Overall explanation is low indicating that important explanatory variables (such as exogenous changes in demand and other specialized facilities) have been omitted.

In spite of the low explanatory power of facility acquisition, comparison of the average change in market share for hospitals acquiring a particular specialized facility with the market share of those hospitals which already had the facilities at the beginning of the period is suggestive. Table 2 indicates the average change in market share of hospitals adding each of the six specialized facilities. In each of the six cases the change in market share is positive. On the other hand Table 2 also indicates that market shares of hospitals which already had the facilities at the beginning of the period declined in five out of six cases. Hospitals which already had the facilities at the beginning of the period tended to experience a decline in market share while hospitals acquiring facilities tended to experience an increase in market share.
<table>
<thead>
<tr>
<th>Specialized Facility</th>
<th>Average Change in Market Share of Hospitals Acquiring Specialized Facility</th>
<th>Average Change in Market Share of Hospitals Not Acquiring Specialized Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical School</td>
<td>+ .058</td>
<td>- .087</td>
</tr>
<tr>
<td>Dental Surgical</td>
<td>+ .058</td>
<td>- .098</td>
</tr>
<tr>
<td>Physical Therapy</td>
<td>+ .048</td>
<td>- .016</td>
</tr>
<tr>
<td>Psychiatric</td>
<td>+ .116</td>
<td>+ .004</td>
</tr>
<tr>
<td>Radioisotope</td>
<td>+ .028</td>
<td>- .031</td>
</tr>
<tr>
<td>Cobalt-Radium</td>
<td>+ .031</td>
<td>- .080</td>
</tr>
</tbody>
</table>
4.2 Effect of Capital on Short-Run Costs of Providing Services

The various ways in which acquisition of capital may be expected to affect operating costs have been outlined in 3.1.2 above. If possibilities of substituting capital for other factors exists or if economies of scale exist, additions to capital may decrease average short-run costs. If acquisition of capital necessitates acquisition of complementary inputs (such as maintenance, electricity, etc.) which increase operating expenses, short-run costs may increase. If new capital allows the production of new services, additional inputs are likely to be required so that total short-run costs of providing services increase (of course, with the production of new services total revenue would be likely to increase also).

It is important to analyze the effect of capital acquisition upon short-run costs of providing hospital services for at least two reasons. First, evidence on the extent of economies of scale can be used to determine whether the existing distribution of hospital facilities is efficient. Second, since current capital acquisition affects future costs and thus future net revenue, funds for future investment will be affected by current investment. Thus, evidence on the effect of capital acquisition on costs can be used to determine whether future investment will improve the allocation of facilities.
Because considerable empirical work has been devoted to the question of estimating long-run average costs of providing hospital care, a brief review of some of the major empirical studies will be made before developing an empirical model for determining the effect of capital on costs.

4.2.1 Empirical Hospital Cost Studies: A Review

Most of the empirical studies which have been undertaken have been concerned with estimating the long-run average cost curve in an attempt to determine if economies of scale exist. In analyzing these studies it is important to bear in mind four questions: 1) is there reason to believe that the estimated curve corresponds to the theoretical construct (i.e. is the estimated curve really the theoretical long-run cost curve), 2) are the estimates subject to simultaneous equation bias, 3) have the effects of specialized facilities on costs as well as differences in size (bed capacity) been taken into account, and 4) have the data been appropriately adjusted for variations in input costs?

All estimates of the long-run average cost curve are based on the obvious, but implicit, assumption that observed points in fact lie on the long-run average cost curve. This would be true only if hospitals hire inputs, including capital, so as to minimize the cost of producing any given output. If all factors are
hired to the point where the value of their marginal product equals their cost, the firm will be operating along its long-run average cost curve. It has been argued in Chapter 3, above, however, that hospitals do not acquire capital services according to the relationship of marginal product to cost, but rather according to the availability of internal funds. The hospital will be operating on its short-run cost curve (since non-capital factors are hired according to marginal productivity conditions), but it is unlikely that it will employ an optimal amount of capital. Observed points, therefore, will in general lie on various short-run cost curves but not on the long-run average cost curve. Failure to recognize this point is a very serious weakness of most previous studies. Instead of attempting to estimate the long-run cost curve directly, an alternative is to estimate short-run cost curves for various amounts and types of capital.

Another shortcoming of the hospital cost studies undertaken previously is the statistical estimating technique used. Reliance has been placed upon ordinary least-squares regression estimation of the cost curve; this technique is inapplicable, however, when output is not exogenously determined. Application of ordinary

---

3 See, for example, James M. Henderson and Richard E. Quandt, Microeconomic Theory (New York: McGraw-Hill, 1958), Ch. 3.
4 In industries where prices are set by a regulatory agency output is determined by the demand curve and is exogenous to the firm so that least-squares estimation is appropriate. See, for example, Marc Nerlove, "Returns to Scale in Electricity Supply," in Carl Christ (ed.), Measurement in Economics: Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld (Palo Alto: Stanford University Press, 1963).
least-squares regression analysis to the estimation of the cost curve yields biased, inconsistent parameter estimates since output is not independent of the error in the equation.\textsuperscript{5} Consistent estimates can be obtained only with the use of a simultaneous equation model and appropriate simultaneous equation estimation techniques. For purposes of comparison with previous studies, however, the next section will apply ordinary least-squares estimation to the cost function. Consistent estimation of the cost curve is postponed until section 4.6 in which a simultaneous equation model of output and factor input determination is developed.

In addition to estimating inappropriate curves (long-run as opposed to short-run) and to using inappropriate estimation techniques, previous studies have frequently not taken account of the effects of specialized facilities and of variations in input prices on costs.

P. Feldstein was the first economist to apply statistical techniques to estimation of the long-run cost curve of hospitals.\textsuperscript{6} He found total cost to be a linear function of output. In this estimation, however, no adjustment is made for differences in specialized facilities and services among hospitals or for

\textsuperscript{5} See, for example, Arthur S. Goldberger, \textit{Econometric Theory} (New York: John Wiley and Sons, 1964).

\textsuperscript{6} Paul J. Feldstein, \textit{An Empirical Investigation of the Marginal Cost of Hospital Services} (Chicago: University of Chicago Graduate Program in Hospital Administration, 1961).
differences in factor costs.\textsuperscript{7}

Berry grouped hospitals according to specialized facilities and estimated cost curves for each group separately.\textsuperscript{8} In general, average costs tended to be constant, although there was some slight evidence of declining average costs in a few groups. Berry's data were unadjusted for differences in factor costs.

Cohen's estimation revealed U-shaped average cost curves with minimum points between 200 and 300 beds.\textsuperscript{9} Construction of the variables used in the estimation, however, raise some question as to the proper interpretation of the estimation.\textsuperscript{10}

Carr and Feldstein stratified a sample of hospitals into groups with approximately the same number of specialized facilities.\textsuperscript{11} Estimated average cost curves were U-shaped with the average cost curve shifting upward as hospital size increases to about 100 beds, and then shifting downward.

\textsuperscript{7} For more details on this and other cost estimation studies see Appendix C.

\textsuperscript{8} Ralph Edward Berry, Jr., Competition and Efficiency in the Market for Hospital Services: The Structure of the American Hospital Industry, unpublished doctoral dissertation, Harvard University, 1965.


\textsuperscript{10} For more details, see Appendix C.

Ingbar and Taylor found an inverted U-shaped cost curve based upon a sample of hospitals in Massachusetts ranging in size from 31 to 332 beds.\footnote{12}

M. Feldstein found an inverted U-shaped average cost curve for hospitals ranging in size from 72 to 117 beds, declining average cost curves for hospitals ranging in size from 118 to 488 beds, and U-shaped cost curve for hospitals ranging in size from 489 to 1064 beds with a minimum point at 1985 beds.

Because of the weaknesses of previous studies and considerable diversity of results, the next section will develop an empirical model circumventing many of the weaknesses. New estimates of the average cost curve based upon this model will be given in section 4.2.4.

\subsection*{4.2.2 Empirical Model for Estimating Hospital Average Costs}

In order to prevent the weaknesses of previous studies, the empirical model to be developed here will estimate short-run average cost curves for various size groups of hospitals and will adjust for differences in wage costs and specialized facilities.


The basic empirical model average cost of providing hospital care is as follows:

$$SRAC_{adj} = a (1/Q) + b + cQ + d_1 F_1 + \ldots + d_n F_n + u$$

for each size group of hospitals where $SRAC_{adj} =$ short-run average cost adjusted for regional differences in wages, $Q =$ average daily census, $F_i =$ specialized facility (equal to one if hospital has facility, equal to zero if hospital does not have facility).

The model is formulated in the average cost form rather than total cost to reduce the danger of heteroscedasticity. The variable $(1/Q)$ is included to estimate short-run fixed costs.

Hospitals are stratified into samples of various size groups. The various size groups are estimated separately so that different short-run cost curves corresponding to various size plants are estimated.

The effects of wage differences are taken into account by adjusting the cost data so that they reflect "real" costs. More details are given in the following section.

---

14 Short-run costs are, as defined in section 3.1.2., operating expenses so that some non-capital expenses may be fixed.

The effect of specialized facilities on costs is estimated by entering possession of these facilities directly into the regression equation as explanatory variables. In this way it is possible to infer from the results the short-run cost curves for each size plant of hospitals without any of the specialized facilities as opposed to hospitals with some or all of the facilities.

As indicated earlier, the average cost model developed in this section ignores problems of simultaneous equation bias induced by regression of average cost on output, an endogenous variable. Simultaneous equation estimation of the cost function is postponed until section 4.6.

4.2.3 Data

Data on hospitals in 21 metropolitan areas in 1966 and in 15 metropolitan areas in 1963 were collected from Guide Issues published by the American Hospital Association.\(^{16}\) Cities were selected to correspond with available data on hospital wages published by the Bureau of Labor Statistics for 1963 and 1966.\(^{17}\)

Data were stratified into six size groups: 0–99 bed hospitals, 100–199, 200–299, 300–399, 400–499, 500 and more bed hospitals.

\(^{16}\) American Hospital Association, Hospitals.

Specialized facilities included dental surgical, physical therapy, outpatient, psychiatric, radioisotope therapy, cobalt therapy, and radium therapy. Affiliations with medical and nursing schools were also included. Although various types of specialized facilities, such as artificial kidney equipment, might significantly affect costs, limitations of available data prevented more comprehensive examination of the effect of specialized facilities on costs.

It was not possible to obtain cost data corresponding to the theoretical concept of short-run costs since depreciation expenses are not shown separately. Rather than use total expense data (which include depreciation expenses) total payroll expenses were used as a proxy for short-run costs. Since short-run costs have been defined as operating expenses, use of payroll expenses as a proxy may be partially justified by the fact that payroll expenses represent approximately 60 to 70 percent of all operating expenses. If available, however, it would have been desirable to include costs of materials, supplies, etc.

In order to adjust cost data for differences in wages, hospital wages in various metropolitan areas collected by the Bureau of Labor Statistics were used. It was assumed that wages of various employee classifications varied in a similar manner across metropolitan areas so that an index based upon one type
of employee classification would accurately reflect differences in wages of all types of employee classifications.\textsuperscript{18} Evidence of the validity of this assumption is presented in Table 3.

Although medical technician salaries did not seem as strongly correlated with other hospital employee classifications, deflating payroll expenses by a wage index based on the general duty registered nurse weekly earnings should be more accurate than assuming that the "true" average wage of a hospital's employees is the same for all hospitals.

Payroll expenses data were adjusted as follows:

\[
PE_{\text{adj}} = \frac{PE_{\text{actual}}}{(RN_m/RN)}
\]

where \(RN_m\) is weekly earnings of general duty registered nurse in mth metropolitan area and RN is weekly earnings of general duty registered nurse for all areas. If the wage level is five percent higher than average in a given city, payroll expenses of hospitals in that city will be divided by 1.05 in order to derive the "true" labor cost of providing hospital services.

4.2.4 Results

Tables 4 and 5 give estimates of the short-run average cost

\textsuperscript{18} Johnston has shown that the appropriate factor price index is a weighted geometric mean of price relatives. If the factor prices are proportional, as postulated here, it is not necessary to know parameters of the production function. J. Johnston, Statistical Cost Analysis (New York: McGraw-Hill, 1960), p. 170-176.
<table>
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<th>1966</th>
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<td>General Duty RN</td>
<td>LVN</td>
<td>Nursing Aid</td>
<td>Med. Tech.</td>
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<td>.67</td>
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</tr>
<tr>
<td>LVN</td>
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<td>1.0</td>
<td>.69</td>
<td>.62</td>
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<td>Nursing Aid</td>
<td></td>
<td></td>
<td>1.0</td>
<td>.75</td>
</tr>
<tr>
<td>Medical Technician</td>
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<td></td>
<td></td>
<td>1.0</td>
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</table>

<table>
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<th>1963</th>
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</tr>
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</tr>
<tr>
<td>LVN</td>
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<td>.83</td>
<td>.68</td>
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<tr>
<td>Nursing Aid</td>
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<td>.75</td>
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<tr>
<td>Medical Technician</td>
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TABLE 4: AVERAGE COST REGRESSION COEFFICIENT ESTIMATES EXCLUDING SPECIALIZED FACILITIES, 1966

<table>
<thead>
<tr>
<th>Bed Size Group</th>
<th>1/Census</th>
<th>Constant</th>
<th>Census</th>
<th>( R^2 )</th>
</tr>
</thead>
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<td>0-99</td>
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<td>.73</td>
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<td>[.06]</td>
<td>[.18]</td>
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<td>.15</td>
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<td>[.41]</td>
<td>[1.24]</td>
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</table>

t-scores shown in brackets
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<tr>
<th>Bed Size Group</th>
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<th>R²</th>
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<td>.003</td>
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<td>10</td>
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<td>.001</td>
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<td>[.12]</td>
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<tr>
<td>500 +</td>
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<td>.01</td>
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<td>[.59]</td>
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</tbody>
</table>

t-scores shown in brackets
curve for 1966 and 1963 respectively when no adjustment is made for specialized facilities. As indicated by the plotting of the 1966 curves in Figure 11, short-run cost curves tend to be U-shaped with minimum average cost points rising gradually as size of plant increases. In 1963, as shown in Figure 12, the U-shaped cost curves tend to have minimum points at roughly the same level of average cost indicating a constant returns to scale envelope.

These results are substantially modified, however, when adjustment is made for specialized facilities. Tables 6 and 7 give new estimates of the short-run curves when all specialized facilities are included as explanatory variables. Tables 8 and 9 give estimates based only upon important specialized facilities. These curves are plotted in Figures 13 and 14. In 1966, the envelope of short-run curves tends to indicate increasing returns to scale throughout the observed range rather than decreasing returns. Decreasing costs are also evident in 1963, rather than constant before adjusting for specialized facilities.

Cost curves which are unadjusted for the influence of specialized facilities also suggest the inverted U-shaped envelope cost curve up to the 300 bed size hospital found in earlier studies.19

19 This was particularly true of the Carr and Feldstein study, "Relationship of Cost to Hospital Size," the Ingbar and Taylor study, Hospital Costs in Massachusetts, and the M. Feldstein study, Economic Analysis of Health Service Efficiency.
TABLE 6: AVERAGE COST REGRESSION COEFFICIENT ESTIMATES INCLUDING SPECIALIZED FACILITIES, 1966

<table>
<thead>
<tr>
<th>Bed Size</th>
<th>1/Q</th>
<th>Constant</th>
<th>Q</th>
<th>M</th>
<th>N</th>
<th>D</th>
<th>PT</th>
<th>Out</th>
<th>Psy</th>
<th>RI</th>
<th>Cob</th>
<th>Rad</th>
<th>R²</th>
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<tbody>
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</tbody>
</table>

\( t \)-scores in brackets

Q=Census, M=Medical school affiliation, N=Nursing school affiliation, D=Dental surgical facility, PT=Physical therapy facility

Out=Outpatient Dept., Psy=Psychiatric facility, RI=Radioisotope facility, Cob=Cobalt facility, Rad=Radium facility
### TABLE 7: AVERAGE COST REGRESSION COEFFICIENT ESTIMATES INCLUDING SPECIALIZED FACILITIES, 1963

<table>
<thead>
<tr>
<th>Bed Size</th>
<th>1/Q</th>
<th>Constant</th>
<th>Q</th>
<th>M</th>
<th>N</th>
<th>D</th>
<th>PT</th>
<th>Out</th>
<th>Psy</th>
<th>RI</th>
<th>Cob</th>
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<td>-1.34</td>
<td>1.92</td>
<td>-.41</td>
<td>.23</td>
<td>.31</td>
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<tr>
<td>200-299</td>
<td>-3982</td>
<td>69</td>
<td>-.11</td>
<td>2.75</td>
<td>-.58</td>
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<td>-.08</td>
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<td>1.35</td>
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<td>.07</td>
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<td>4.62</td>
<td>1.33</td>
<td>3.98</td>
<td>1.71</td>
<td>.28</td>
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<tr>
<td>400-499</td>
<td>18,343</td>
<td>-70</td>
<td>.11</td>
<td>-1.95</td>
<td>1.11</td>
<td>4.62</td>
<td>1.13</td>
<td>4.98</td>
<td>.20</td>
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<td>[1.51]</td>
<td></td>
<td></td>
<td>[1.49]</td>
<td></td>
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<tr>
<td>500+</td>
<td>11,469</td>
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<td>.01</td>
<td>7.21</td>
<td>-4.23</td>
<td>-3.68</td>
<td>6.62</td>
<td>-4.25</td>
<td>.33</td>
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<td>[.03]</td>
<td>[.70]</td>
<td>[1.92]</td>
<td>[-1.56]</td>
<td>[-.92]</td>
<td></td>
<td>[1.91]</td>
<td></td>
<td></td>
<td>[-.58]</td>
<td></td>
</tr>
</tbody>
</table>

t-scores in brackets

Q=Census, M=Medical school affiliation, N=Nursing school affiliation, D=Dental surgical facility, PT=Physical therapy facility

Out=Outpatient Dept., Psy=Psychiatric facility, RI=Radioisotope facility, Cob=Cobalt facility
### Table 8: Average Cost Regression Coefficients Including Important Facilities, 1966

**Bed Size**

<table>
<thead>
<tr>
<th>Size</th>
<th>Equation</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-99</td>
<td>$AC = 510 \frac{1}{Q} - 3.46 + .34 Q + .13 D + 5.37 \text{ Rad}$</td>
<td>.74</td>
</tr>
<tr>
<td></td>
<td>$[10.6] \quad [-.72] \quad [4.61] \quad [.04] \quad [1.39]$</td>
<td></td>
</tr>
<tr>
<td>100-199</td>
<td>$AC = 2118 \frac{1}{Q} - 17 + .22 Q + 4.92 \text{ RI} + 2.77 \text{ Rad}$</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>$[1.01] \quad [-.43] \quad [1.14] \quad [1.86] \quad [1.04]$</td>
<td></td>
</tr>
<tr>
<td>200-299</td>
<td>$AC = -2956 \frac{1}{Q} + 54 - .06 Q + 5.97 M + .62 \text{ Out} + 3.74 \text{ Psy} + 4.39 \text{ Cob}$</td>
<td>.32</td>
</tr>
<tr>
<td></td>
<td>$[.68] \quad [1.19] \quad [-.49] \quad [2.97] \quad [2.30] \quad [1.51] \quad [1.86]$</td>
<td></td>
</tr>
<tr>
<td>300-399</td>
<td>$AC = 16,805 \frac{1}{Q} - 91 + .19 Q + 7.61 M + 5.49 D + 3.82 \text{ Psy} + 6.10 \text{ Cob}$</td>
<td>.34</td>
</tr>
<tr>
<td></td>
<td>$[1.20] \quad [-.87] \quad [1.03] \quad [1.20] \quad [2.58] \quad [1.59] \quad [2.76]$</td>
<td></td>
</tr>
<tr>
<td>400-499</td>
<td>$AC = 33,148 \frac{1}{Q} - 149 + .25 Q + 3.48 \text{ Psy} + 2.40 \text{ Cob}$</td>
<td>.25</td>
</tr>
<tr>
<td></td>
<td>$[2.18] \quad [-1.72] \quad [1.97] \quad [1.65]$</td>
<td></td>
</tr>
<tr>
<td>500+</td>
<td>$AC = 14,053 \frac{1}{Q} - 22 + .03 Q + 5.8 M + 7.38 D + 6.75 \text{ Psy} + .81 \text{ Cob}$</td>
<td>.32</td>
</tr>
<tr>
<td></td>
<td>$[1.65] \quad [-.79] \quad [1.63] \quad [1.99] \quad [2.20] \quad [2.35] \quad [.29]$</td>
<td></td>
</tr>
</tbody>
</table>

$t$-scores in brackets

$AC =$ Average cost, $Q =$ Census, $M =$ Medical school affiliation, $D =$ Dental surgical facility, $Out =$ Outpatient Department, $Psy =$ Psychiatric facility, $RI =$ Radioisotope facility, $Cob =$ Cobalt facility, $Rad =$ Radium facility
### Table 9: Average Cost Regression Equations Including Important Facilities, 1963

<table>
<thead>
<tr>
<th>Bed Size</th>
<th>AC Equation</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-99</td>
<td>( AC = 389 \frac{1}{Q} + 9.75 + .14 Q - 3.10 D + 1.47 \text{RI} )</td>
<td>.22</td>
</tr>
<tr>
<td></td>
<td>([2.36] ) ([.91] ) ([1.06] ) ([- .85] ) ([.31] )</td>
<td></td>
</tr>
<tr>
<td>100-199</td>
<td>( AC = 2558 \frac{1}{Q} - 25 + .23 Q + 3.73 D - .64 \text{Cob} )</td>
<td>.24</td>
</tr>
<tr>
<td></td>
<td>([2.28] ) ([-1.15] ) ([2.21] ) ([2.42] ) ([- .36] )</td>
<td></td>
</tr>
<tr>
<td>200-299</td>
<td>( AC = -4621 \frac{1}{Q} + 74 - .12 Q + 2.94 \text{M} - .17 D + 1.74 \text{Psy} + 4.40 \text{Cob} )</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>([- .82] ) ([1.23] ) ([- .82] ) ([1.58] ) ([- .12] ) ([.64] ) ([3.27] )</td>
<td></td>
</tr>
<tr>
<td>300-399</td>
<td>( AC = 6882 \frac{1}{Q} - 22 + .06 Q + 6.01 \text{M} + 4.45 \text{Out} + 3.19 \text{Cob} )</td>
<td>.25</td>
</tr>
<tr>
<td>400-499</td>
<td>( AC = 14,226 \frac{1}{Q} - 48 + .09 Q + 3.61 \text{D} + 1.64 \text{Psy} + 4.06 \text{Cob} )</td>
<td>.18</td>
</tr>
<tr>
<td></td>
<td>([.46] ) ([- .29] ) ([.38] ) ([1.72] ) ([.78] ) ([1.38] )</td>
<td></td>
</tr>
<tr>
<td>500+</td>
<td>( AC = 13,326 \frac{1}{Q} - 14 + .02 Q + 7.12 \text{M} + 5.60 \text{Psy} )</td>
<td>.24</td>
</tr>
<tr>
<td></td>
<td>([1.53] ) ([- .55] ) ([1.05] ) ([2.15] ) ([1.69] )</td>
<td></td>
</tr>
</tbody>
</table>

\( t \)-scores shown in brackets

AC=Average cost, Q=Census, M=Medical school affiliation, D=Dental surgical facility, Out=Outpatient Department, Psy=Psychiatric facility, RI=Radioisotope facility, Cob=Cobalt facility
This inverted U-shape disappears after possession of specialized facilities is included as an explainer of average cost. Explanation of this phenomena lies in the fact that average cost estimates of small hospitals (say, less than 150 beds) are virtually the same whether or not specialized facilities are included since few hospitals in this size range have many specialized facilities. Average cost of hospitals in the 150 to 300 bed size range, however, are shifted significantly downward by separating out the extra costs attributable to the specialized facilities. Overall envelope is, therefore, constant or declining in the smaller hospital range, rather than an inverted U-shape.

Estimates of the cost curves unadjusted for differences in wage costs revealed substantially the same results indicating that failure to adjust for differences in wages may not be a serious weakness.

In summary, the findings of this cost estimation have reconciled some of the diversity of previous findings. If proper adjustment for specialized facilities is made, average cost curves exhibit economies of scale with respect to bed size. The inverted U-shape cost curve for smaller hospitals disappears. Acquisition of specialized facilities, holding size of hospital constant, increases average cost of providing hospital services.
4.3 Relationship of Prices Charged to Costs

The standard view of the determination of prices is that prices are simply set equal to average costs without regard to supply or demand conditions. As pointed out in Chapter 2, this view is held not only by members of the hospital profession (who might well have a vested interest in purporting it to be true), but also by some economists.

If the standard view of hospital price determination is correct, the ratio of price to average cost is a constant and does not vary in any systematic way with demand or supply conditions. The next section will examine the evidence to see if this view is upheld.

4.3.1 Empirical Model

To test the hypothesis that the ratio of prices to average costs is not a constant, several demand and supply factors which might reasonably be expected to affect this ratio will be examined to determine if they "explain" any variation in the price--average cost ratio.

As indicated in Chapter 3, the quantity which is demanded at any given price charged by the hospital is likely to depend upon the level of income, extent of insurance coverage, and age composition of the area served by the hospital. Two empirical
studies reported on in Chapter 2 found economic variables such
as income and insurance to be important explanators of demand. Income and insurance, therefore, seem likely candidates to use
as explanators of the price-cost ratio. Also, since elderly
people tend to require more hospitalization than other age groups,
a higher percentage of the population age 65 or older might also
increase demand.

In the theoretical model presented above, hospitals
operating at capacity are expected to have higher prices than
hospitals with similar demand for whom the capacity constraint
is not binding (see Figure 7). Other things equal, therefore,
hospitals operating at high levels of capacity might be expected
to have a higher price-average cost ratio.

Other supply conditions which might affect the ratio are
"scarcity" of beds (available beds per capita), concentration
ratio (whether few or many hospitals provide care), and alternatives
to private hospital care (availability of city, county, state
charity hospitals). "Scarcity" of beds, in particular, is
occasionally blamed for high hospital prices. Accordingly,
available beds per capita will be included to see if it is

---

20 Rosenthal, *The Demand for General Hospital Facilities* and
P. Feldstein, "The Demand for Medical Care."

21 Collins and Preston have investigated the relationship of
price-cost ratios to measures of concentration for manufacturing
firms. See, Norman R. Collins and Lee E. Preston, *Concentration
and Price-Cost Margins in Manufacturing Industries* (Berkeley:
negatively related to the price-cost ratio. The price-cost ratio might also be expected to be positively related to the extent of concentration in the provision of services and negatively related to the availability of governmental care.

Therefore, to test the hypothesis that prices are set equal to cost the following empirical model is postulated:

\[ P/AC = a + bY + cI + dM + e Occ + f B/Pop + g CR + hG + u \]

where \( P \) is price, \( AC \) is average cost, \( Y \) is per capita income, \( I \) is insurance, \( M \) is percent of population 65 years of age and older, \( Occ \) is occupancy rate, \( B/Pop \) is beds per capita, \( CR \) is concentration ratio, and \( G \) is governmental care.

Expected signs of the coefficients are as follows:
\( b, c, d, e, g > 0; \ f, h < 0. \)

4.3.2 Data

Data on prices charged for various types of rooms are available from the American Hospital Association. The first measure of price used in the study is the average charge for a

Some authors seem to think that increasing the number of beds ("supply" of care) will hold prices down. As can be seen from Figure 7, if the capacity constraint is not binding, increasing the number of beds will have no direct effect on prices (although it may affect operating costs and therefore optimal output and prices).

two-bed room. Cross-section regressions based on the fifty state
data are repeated for each year during the period 1960-1966. Prices
in 1960 and 1961 are based on average charge for all short-term
non-federal hospitals. Price data from 1962 to 1966 are based on
the average charge for all short-term non-governmental, non-profit
hospitals (i.e. city, county, and state hospitals are excluded as
well as hospitals organized as corporations, partnerships, and
proprietorships).

The second measure of price is patient revenue per patient
day. Again, data are provided by the American Hospital Association.\footnote{24}
This measure has the advantage of including the effect of ancillary
service charges. The principal difficulty with using patient
revenue data is that not all patient revenue stems from prices
charged by the hospital. Blue Cross commonly reimburses hospitals
for the care of its beneficiaries not on the basis of prices charged
by the hospital but by its average cost. A hospital with 90 percent
of its patients covered by Blue Cross and 10 percent of its patients
private paying patients who pay the price charged by the hospital
would have lower revenue than a hospital charging the same price
treating the same number of patients none of whom were covered by
Blue Cross.\footnote{25}

\footnote{24}{American Hospital Association, "Guide Issues," \textit{Hospitals},
various annual issues.}
\footnote{25}{If price charged by hospital is less than average cost,
Blue Cross typically pays price rather than average cost. See,
Blue Cross Association, "Hospital Reimbursement Methods of Blue
Cross Plans," in \textit{Third-Party Reimbursement for Hospitals} (Bloomington,
Indiana: Indiana University, 1965).}
As shown by a recent study by Reed and Carr, Blue Cross and Blue Shield plans account for 55 percent of total gross enrollment for hospital benefits in New England as compared with 24 percent in West South Central States. To determine the price charged non-Blue Cross patients from patient revenue requires calculating revenue received from non-Blue Cross patients (total patient revenue less receipts from Blue Cross). The ratio of non-Blue Cross revenue per non-Blue Cross patient day is the same as non-Blue Cross patient revenue divided by non-Blue Cross total costs so that it is unnecessary to calculate Blue Cross patient days (i.e. \( PR/Q \div TC/Q = PR/TC \)). Making the assumption (as the Blue Cross organization does) that Blue Cross patients have the same average cost of care as non-Blue Cross patients, non-Blue Cross cost equals total cost less Blue Cross expenditures (since Blue Cross expenditures are set equal to the cost of caring for Blue Cross patients). The appropriate ratio is then:

\[
\frac{\text{non-Blue Cross revenue}}{\text{non-Blue Cross cost}} = \frac{\text{total patient revenue} - \text{BC expenditures}}{\text{total cost} - \text{BC expenditures}}
\]

in states where Blue Cross reimburses on the basis of average cost.

Unfortunately, data on expenditures for hospital care of Blue Cross

\[26\]

beneficiaries are not currently available; however expenditure data for 1966 for both hospital and surgical care under Blue Cross—Blue Shield are available. This measure obviously overstates the desired measure and thus biases the estimate of the ratio. Rather than neglect entirely the effect of Blue Cross reimbursement, total hospital and surgical Blue Cross—Blue Shield expenditures per capita is included directly as an explanatory variable of the revenue—total cost ratio. Since data are available for 1966 only, these values are used for all years.

The revenue data also do not reflect prices charged by the hospital to the extent that some charges are not collected. No attempt is made to correct for any bias this may impart to the measure since bad debt information is not available.

The appropriate measure of cost depends upon whether the hospital sets prices equal to all costs per patient day or equal to variable costs per patient day with a markup to cover fixed expenses. Two different measures were used: total expenses and payroll expenses (as a proxy for variable expenses).

In examining the mean ratio of revenues from patients to total expenses and its trend over time, it is important to point out that total expenses may exceed patient revenue in some cases

since various expenses (such as running a cafeteria, etc.) may be included in total expenses but proceeds from these services are not included in patient revenue. Patient revenue divided by payroll expenses obviously overstates profitability, but its trend over the period should be of interest since it will indicate whether or not prices have risen more rapidly than wage costs.

Available data on insurance coverage by states are also very meager. The Health Insurance Institute annually publishes the number of people in each state with some hospitalization insurance. This measure does not capture the effects of broader coverage. As Reed and Carr point out:

"Per capita health insurance benefit expenditures in Michigan were nearly three times those of Arkansas, although the percent of the population with health insurance was only 67 percent greater." 29

The Reed and Carr study does provide total hospital and surgical benefit expenses by states for 1966. These data are used to construct a measure of the extent of non-Blue Cross insurance coverage:

\[
I/\text{Pop} = \frac{\text{Total Insurance Expenditures} - \text{BC Expenditures}}{\text{Population} - \text{No. enrolled in BC plan}}
\]

Again, since this information is available only for 1966, this measure is used for all years.

---

28 Health Insurance Institute, Annual Survey of Hospitalization Insurance.

29 Reed and Carr, "Private Health Insurance."
Desirable measures of the concentration of the provision of hospital services in a few hospitals might include percent of patient days occurring in the four or eight largest hospitals or percent of patient days occurring in hospitals with 500 or more beds. Since this information was not readily available, it was decided to use the average size of hospital as a measure of the concentration of economic power.

4.3.3 Results

Preliminary ordinary least-squares regression found the percentage of the population age 65 or over, occupancy rate, and average size of hospital to be insignificant in explaining the price-cost ratio. Accordingly, these variables were dropped from further investigation.

The relationship between the price-cost ratio and available beds per capita was found to be positive rather than negative as predicted. Simple correlation coefficients were as follows: \( r = .45, .30 \) for beds per capita and price/average cost, price/average payroll cost in 1965, respectively. The theoretical model presented in Chapter 3 would explain this phenomena by pointing out that states with high price-cost ratios would have higher

---

30 One possible reason for the insignificance of these variables is the high degree of aggregation. If data on cities or counties could be used instead of state data, measures such as concentration might be significant.
net patient revenue and construct more beds so that those states
would tend to have more beds per capita. Since this explanation
implies that price-cost ratios explain number of beds per capita
rather than the reverse causation, it was dropped from the
equation.

Results of the ordinary least-squares regressions relating
room charge divided by average total expenses are shown in Table 10.
Income is significantly positive for all years studied. Other
things equal, the higher the per capita income of a state the higher
will be the markup of room charges over cost. Insurance appears
with a negative sign (rather than positive as predicted), but it
is insignificant. This probably reflects the inadequacy of total
hospital and surgical expenditures as a proxy for hospital insurance
coverage. Government provision of hospital services is negatively
related to the price-cost ratio. Government hospitals tend to
exert a competitive influence on the charges of private hospitals
by providing an alternative to private care. Overall explanation
of the regressions is significantly different from zero so that
the hypothesis that prices are set identically equal to zero may
be rejected.

Results of the ordinary least-squares regressions relating
room charge divided by average payroll expenses are shown in
Table 11. Results are similar to those obtained in the average
<table>
<thead>
<tr>
<th>Year</th>
<th>Constant</th>
<th>Income</th>
<th>Insurance</th>
<th>Government</th>
<th>$R^2$</th>
<th>Mean P/ATC</th>
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</thead>
<tbody>
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<td>-.019</td>
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<td></td>
</tr>
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<td>-.014</td>
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<td>-.019</td>
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</tr>
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<td>[-1.20]</td>
<td></td>
<td></td>
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</tr>
<tr>
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<td>-.001</td>
<td>-.03*</td>
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<td>.519</td>
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<td>[-.99]</td>
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<td>-.002</td>
<td>-.05**</td>
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<td>.502</td>
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<td>[-3.17]</td>
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</tr>
<tr>
<td>1960</td>
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<td>.0001**</td>
<td>-.001</td>
<td>-.06**</td>
<td>.45</td>
<td>.516</td>
</tr>
<tr>
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<td>[4.04]</td>
<td>[-.95]</td>
<td>[-3.54]</td>
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</tbody>
</table>

* Significant at 5 percent level.
** Significant at 1 percent level.
<table>
<thead>
<tr>
<th>Year</th>
<th>Constant</th>
<th>Income</th>
<th>Insurance</th>
<th>Government</th>
<th>$R^2$</th>
<th>Mean P/APC</th>
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<td>-.003</td>
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<td>.847</td>
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<td>[ .28]</td>
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<td>1963</td>
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<td>-.005**</td>
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<td>.856</td>
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<td>[-2.03]</td>
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<td></td>
</tr>
</tbody>
</table>

* Significant at 5 percent level.
** Significant at 1 percent level.
total cost case. Income is significantly positive; insurance and
government provision of services are negative or insignificant.
Overall explanation is somewhat lower.

Results based upon the revenue measure of prices are given
in Table 12 and Table 13. Although overall explanation is
moderately high, most of the explanatory power stems from
institutional sources rather than behavioral. Blue Cross
reimbursement tends to decrease significantly the hospital's
markup over costs. This, however, can be attributed to the
institutional arrangement by which Blue Cross reimburses hospitals
on the basis of cost rather than charges. Similarly, government
provision of hospital services enters with a positive sign
suggesting that where governmental agencies directly provide
care rather than reimbursing private hospitals for care of
indigent patients (normally on the basis of costs) hospital
revenue is relatively higher (although prices charged private
patients may be less).

The failure of income to significantly affect the revenue-
total cost ratio may stem from the inappropriate measure of hospital
aggregate charges. To the extent that Blue Cross is more pre-
dominant in higher income areas, the higher revenue induced by
income would be offset by the lower revenue induced by Blue Cross
reimbursement arrangements. Simple correlation coefficient
TABLE 12: REGRESSION ESTIMATION OF PATIENT REVENUE/TOTAL EXPENSES

<table>
<thead>
<tr>
<th>Year</th>
<th>Constant</th>
<th>Income</th>
<th>Blue Cross</th>
<th>Insurance</th>
<th>Government</th>
<th>$R^2$</th>
<th>Mean PR/TE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>1.0</td>
<td>.000002</td>
<td>-.002**</td>
<td>-.001</td>
<td>-.004</td>
<td>.43</td>
<td>.981</td>
</tr>
<tr>
<td>1965</td>
<td>1.04</td>
<td>-.000006</td>
<td>-.002**</td>
<td>-.0004</td>
<td>.008</td>
<td>.40</td>
<td>.986</td>
</tr>
<tr>
<td></td>
<td>[-.35]</td>
<td>[-3.67]</td>
<td>[-.55]</td>
<td>[ .76]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>.98</td>
<td>-.00001</td>
<td>-.001*</td>
<td>.0003</td>
<td>.014</td>
<td>.21</td>
<td>.965</td>
</tr>
<tr>
<td></td>
<td>[-.40]</td>
<td>[ 2.12]</td>
<td>[ .36]</td>
<td>[ 1.12]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td>.98</td>
<td>.00003</td>
<td>-.0015**</td>
<td>-.0015</td>
<td>.008</td>
<td>.27</td>
<td>.969</td>
</tr>
<tr>
<td></td>
<td>[1.36]</td>
<td>[-2.69]</td>
<td>[-1.66]</td>
<td>[ .60]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1962</td>
<td>1.02</td>
<td>.00002</td>
<td>-.002**</td>
<td>-.002*</td>
<td>-.024</td>
<td>.32</td>
<td>.946</td>
</tr>
<tr>
<td></td>
<td>[1.04]</td>
<td>[-3.31]</td>
<td>[-2.27]</td>
<td>[-1.47]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1961</td>
<td>.98</td>
<td>.00001</td>
<td>-.002*</td>
<td>-.001</td>
<td>.004</td>
<td>.15</td>
<td>.952</td>
</tr>
<tr>
<td></td>
<td>[.32]</td>
<td>[-2.15]</td>
<td>[-.60]</td>
<td>[ .19]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>.87</td>
<td>.00002</td>
<td>-.004</td>
<td>.003</td>
<td>.037</td>
<td>.08</td>
<td>.924</td>
</tr>
<tr>
<td></td>
<td>[.20]</td>
<td>[-1.53]</td>
<td>[.78]</td>
<td>[.58]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at 5 percent level.
** Significant at 1 percent level.
<table>
<thead>
<tr>
<th>Year</th>
<th>Constant</th>
<th>Income</th>
<th>Blue Cross</th>
<th>Insurance</th>
<th>Government</th>
<th>$R^2$</th>
<th>Mean PR/TE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>1.88</td>
<td>0.0003</td>
<td>-0.009</td>
<td>-0.021</td>
<td>-0.105</td>
<td>0.04</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td>[0.85]</td>
<td>[-0.89]</td>
<td>[-1.21]</td>
<td>[-0.51]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>1.91</td>
<td>-0.000004</td>
<td>-0.005**</td>
<td>-0.005</td>
<td>0.054*</td>
<td>0.63</td>
<td>1.64</td>
</tr>
<tr>
<td></td>
<td>[-1.20]</td>
<td>[-4.15]</td>
<td>[-1.70]</td>
<td></td>
<td>[2.29]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>1.79</td>
<td>-0.00003</td>
<td>-0.004**</td>
<td>-0.003</td>
<td>0.07**</td>
<td>0.54</td>
<td>1.61</td>
</tr>
<tr>
<td></td>
<td>[-0.71]</td>
<td>[-3.10]</td>
<td>[-1.43]</td>
<td></td>
<td>[2.79]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1962</td>
<td>1.89</td>
<td>-0.00001</td>
<td>-0.006**</td>
<td>-0.006**</td>
<td>0.026</td>
<td>0.60</td>
<td>1.58</td>
</tr>
<tr>
<td></td>
<td>[-0.35]</td>
<td>[-3.37]</td>
<td>[-3.55]</td>
<td></td>
<td>[0.95]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td>1.77</td>
<td>0.000002</td>
<td>-0.003**</td>
<td>-0.004**</td>
<td>0.094**</td>
<td>0.64</td>
<td>1.61</td>
</tr>
<tr>
<td></td>
<td>[0.04]</td>
<td>[-2.95]</td>
<td>[-2.68]</td>
<td></td>
<td>[3.91]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1961</td>
<td>1.84</td>
<td>-0.0001</td>
<td>-0.003**</td>
<td>-0.002</td>
<td>0.064**</td>
<td>0.59</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>[-1.67]</td>
<td>[-3.03]</td>
<td>[-1.33]</td>
<td></td>
<td>[2.46]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>1.59</td>
<td>-0.0003</td>
<td>-0.007</td>
<td>0.001</td>
<td>0.134</td>
<td>0.16</td>
<td>1.53</td>
</tr>
<tr>
<td></td>
<td>[-0.20]</td>
<td>[-1.74]</td>
<td>[0.19]</td>
<td></td>
<td>[1.25]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at 5 percent level.

** Significant at 1 percent level.
between Blue Cross reimbursement and per capita income in 1966 was .50. In order to separate the impact of income, therefore, it is necessary to construct the appropriate measure of private revenue-patient cost ratio described above.

4.4 Internal Funds and Investment

Since non-profit hospitals are legally prevented from distributing dividends to owners, all net patient revenue generated by the hospital must be retained. Hospitals which keep past net patient revenue in the form of liquid assets or financial investments (such as stocks or bonds) are in danger of arousing public indignation over "excessive" profits. If net patient revenue is invested in plant and equipment, however, the threat of a critical public is reduced since this type of investment may be justified on the grounds that it is necessary to meet the "need" for hospital care or provide more extensive and higher quality medical care. It has been hypothesized in section 3.1.4, therefore, that hospitals invest all net patient revenue and contributions in plant and equipment.

To test this hypothesis simple correlation coefficient analysis of the relationship between net patient revenue and investment in plant and equipment will be made.

Ideally, data on individual hospitals over time would be examined to determine the source of funds for all investment
projects and any lags between the acquisition of funds and commencement of investment. Unfortunately, both net patient revenue and detailed investment data are unavailable for individual hospitals.

Since net patient revenue and plant and equipment asset data are available by states for a number of years, correlation coefficients between investment and net patient revenue lagged one year for a cross-section of fifty states in various periods are calculated.

Several difficulties are introduced by this data. First, the theory is intended to explain the expansion of existing hospitals rather than establishment of new hospitals. Including new hospital construction overstates the amount of investment which is to be explained by net patient revenue since only additions to existing hospitals should be considered. Second, data on funds for investment donated by external sources is unavailable. Federal financing of construction as well as private donations could be important sources of funds. Internal net patient revenue, therefore, understates total funds that are available for investment. Third, depreciation data are unavailable so that a proxy measure for net patient revenue must be used:

---

31 Cross-section estimates have tended to exhibit little stability over time. See, for example, Edwin Kuh, Capital Stock Growth: A Micro-Econometric Approach (Amsterdam: North Holland, 1963).

32 Under the Hill-Burton program, hospitals may obtain one-third to two-thirds of the cost of construction from federal sources.
total revenue less payroll expenses. This proxy will be highly correlated with the "true" measure of net revenue if non-payroll expenses are correlated with payroll expenses, but will overstate the absolute amount of funds available for investment.

Since the appropriate absolute values of net revenue and investment cannot be obtained, no attempt is made to test the hypothesis that the coefficient of net revenue in an ordinary least-squares regression of investment on lagged net revenue is identically equal to one; however a correlation coefficient analysis of investment and the proxy measure for net revenue should reveal whether these variables are closely related.

The correlation coefficients between investment over one year and net revenue for previous year for each annual period between 1960 and 1966 are as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966–1965</td>
<td>.72</td>
</tr>
<tr>
<td>1965–1964</td>
<td>.90</td>
</tr>
<tr>
<td>1964–1963</td>
<td>.81</td>
</tr>
<tr>
<td>1963–1962</td>
<td>.86</td>
</tr>
<tr>
<td>1962–1961</td>
<td>.89</td>
</tr>
<tr>
<td>1961–1960</td>
<td>.74</td>
</tr>
</tbody>
</table>
In all periods, the correlation coefficient between investment and lagged net patient revenue are statistically significant at the .01 level. The somewhat lower correlation coefficient in the 1966–1965 period may have been caused by changes in the accounting value of capital induced by Medicare accounting requirements and provisions for depreciation.

4.5 Composition of Investment

It has been hypothesized that hospitals allocate net revenue funds among alternative investment projects so as to maximize future net patient revenue. As a result of this, certain patterns of investment will result depending upon whether 1) the hospital is operating at capacity, 2) economies of scale have been exploited, 3) demand is stagnant or growing, or 4) labor costs are rising rapidly.

Data limitations prevent a direct estimation of the determinants of allocation of investment funds; however substantial data on bed investment and bed utilization rates are available so that it is possible to investigate extensively whether bed investment is more likely to occur when bed utilization rates are high.

Two basic samples of data are used. Data on 346 individual hospitals in 21 major metropolitan areas were obtained for the years 1966 and 1963 from the American Hospital Association.  

---

33 American Hospital Association, "Guide Issues."
Cross-section data for the fifty states were also obtained for the years 1960–1966 from the same source.

Using data on the 346 individual hospitals, the following least-squares estimation was obtained:

\[ BI = -0.22 + 0.37 \text{Occ} \]
\[ t = 2.65 \mid [3.65] \]

where BI is bed investment and Occ is occupancy rate.

Occupancy rate is statistically significant at the .01 level in explaining bed investment. Table 14, containing the average bed investment for various ranges of occupancy rates, reveals this relationship somewhat more clearly. As shown in the table, bed investment declines monotonically with decrease in the range of occupancy rate varying from 15.3 percent increase in beds for hospitals operating at 90–100 percent of capacity to .1 percent decrease in beds for hospitals operating at below 60 percent capacity.

Correlation coefficients between bed investment and occupancy for the fifty state cross-section for various years between 1960 and 1966 are shown in Table 15. Three are significant at the .01 level and in one additional year at the .05 level.

Although far more extensive empirical information is required before the hypothesis that hospitals allocate funds so as to maximize future net patient revenue can be maintained with a great deal of confidence, tentative evidence does suggest that funds are generally allocated to bed investment when occupancy rates are high.
### TABLE 14: MEAN BED INVESTMENT FOR VARIOUS OCCUPANCY RATE RANGES

<table>
<thead>
<tr>
<th>Occupancy Rate</th>
<th>Percent Increase in Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 - 100</td>
<td>15.3 %</td>
</tr>
<tr>
<td>80 - 89</td>
<td>8.4</td>
</tr>
<tr>
<td>70 - 79</td>
<td>5.1</td>
</tr>
<tr>
<td>60 - 69</td>
<td>4.5</td>
</tr>
<tr>
<td>Below 60</td>
<td>-.1</td>
</tr>
</tbody>
</table>
**TABLE 15:** CORRELATION COEFFICIENTS BETWEEN BED INVESTMENT AND OCCUPANCY RATES

<table>
<thead>
<tr>
<th>Year Pair</th>
<th>Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966-1965</td>
<td>.21</td>
</tr>
<tr>
<td>1965-1964</td>
<td>.51**</td>
</tr>
<tr>
<td>1964-1963</td>
<td>.31*</td>
</tr>
<tr>
<td>1963-1962</td>
<td>-.08</td>
</tr>
<tr>
<td>1962-1961</td>
<td>.44**</td>
</tr>
<tr>
<td>1961-1960</td>
<td>.39**</td>
</tr>
</tbody>
</table>

* Significant at 5 percent level.

** Significant at 1 percent level.
4.6 Simultaneous Equation Estimation of Output and Factor Input Determination

Previous empirical work on the economics of hospital care has been concentrated on two aspects: 1) demand for hospital services and 2) long-run costs of providing care. The typical statistical procedure is to estimate a single equation model using ordinary least-squares regression analysis.

This section will show that previous single equation estimations of the demand and long-run cost curves are valid only under rather extreme assumptions. Then a simultaneous equation model will be developed which will allow consistent estimation of the parameters of the demand and cost curves. Empirical estimation will also provide a direct test of the hypothesis that prices of hospital services and short-run factor inputs are determined so as to maximize short-run net patient revenue.

4.6.1 Demand for Hospital Care

In a pioneering work, Rosenthal developed and estimated a demand function for hospital facilities.34 His study was one of the first studies to stress the importance of economic factors in determining the demand for hospital care. Although his study

34 Rosenthal, The Demand for General Hospital Facilities.
represented a major breakthrough challenging the accepted view
that demand was perfectly price inelastic, single equation estimation
of the demand function is, in general, not valid. The observed
relationship between price and quantity may represent the demand
curve, the supply curve, or a combination of both.

It is possible that Rosenthal based his estimation on the
assumption (commonly made in the literature) that hospitals set
price equal to constant long-run average cost. In that case, shifts
in the horizontal supply curve (induced, say, by changes in hospital
wages) would trace out points on the relatively stable (given income,
insurance coverage, age distribution, etc.) demand curve. The
simultaneous equation system (demand and supply) would be recursive
and estimation of the demand equation by itself would be justified.
The system would be similar to the following simple model:

\[
\text{Supply: } \quad p = kw + u_1 \\
\text{Demand: } \quad p = a + bq + cY + u_2
\]

where \(p\) is price, \(q\) is quantity, \(w\) is wages, and \(Y\) is income.
Since \(q\) does not appear in the supply equation, \(p\) is determined by
the first equation and \(q\) may be determined from the second equation
(assuming wages and income to be exogenous).

Section 4.4 above, however, rejected the hypothesis that

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See, for example, Franklin M. Fisher, The Identification
prices are simply set equal to cost or a fixed percentage of cost; instead the price-cost ratio varies in a systematic way with various demand and supply conditions. It is doubtful, therefore, that single equation estimation of the demand equation is justifiable. A simultaneous equation model is required in order to obtain consistent estimates of the demand function parameters.

Since a monopolist does not have a supply curve but rather acts upon the demand curve, a complete system determining prices, output, and levels of factor inputs can become an extremely difficult system to estimate. In order to keep the system as tractable as possible without sacrificing the essentials of the theoretical model, it will be assumed that the demand curve is log linear:

\[ Q = B_0 P^\varepsilon Y^\eta \]  

Demand Function

where \( Q \) is quantity, \( P \) is price, \( Y \) is income, \( -\varepsilon \) is price elasticity of demand, and \( \eta \) is income elasticity of demand. We expect \( \varepsilon \) to be negative, and the income elasticity of demand to be positive (\( \eta > 0 \)). The demand function may be expressed equivalently as follows:

\[ P = B Q^{\varepsilon} Y^{\eta} \]  

Demand Function

where \( B = B_0 \), \( \varepsilon = \frac{1}{\varepsilon} \), and \( \eta = -\frac{\eta}{\varepsilon} \). Therefore, revenue is

\[ R = B Q^\eta Y^{\eta} \]  

Revenue Function.

If the demand curve is price elastic (\( |\varepsilon| > 1 \)), then \( 0 < \varepsilon + 1 < 1 \).
If the demand curve is price inelastic ($|\epsilon| \leq 1$), then $\partial x + l < 0$.

Additional exogenous variables may be added to the demand function if desired, but for simplicity of exposition only income will be considered here.

4.6.2 Cost of Hospital Care

As discussed in Section 4.3 above, previous empirical studies of the average cost of providing hospital care have been based upon ordinary least-squares regression analysis. Ordinary least-squares regression yields unbiased, efficient estimates if the explanatory variables are exogenous. Unless it can be argued that output is exogenously determined, ordinary least-squares estimates may yield inconsistent estimates. 36

The cost function is essentially a structural equation derived from hypotheses regarding hospital motivation. As pointed out in section 4.2 above, estimates of the long-run average cost curve are based on some implicit assumption regarding hospital motivation. If the hospital maximizes profit, for example, then in the long-run observed points will lie on the long-run average cost curve since the hospital will hire factor inputs such that the rate of technical substitution equals ratio of factor prices.

36 For an example of cost estimation for an industry with exogenous output, see Marc Nerlove, "Returns to Scale in Electricity Supply."
If in the long-run the hospital does not employ an optimal quantity of capital services (either because the hospital derives utility from excessive amounts of capital or because it has the funds to purchase excessive amounts of capital), the hospital will not be operating upon the long-run average cost curve.

It is important, therefore, to derive the cost function directly from the hypotheses regarding factor input determination, and estimate the appropriate function derived in this fashion.

The following section will develop a simultaneous equation system based upon the theoretical model of hospital behavior present in Chapter 3. The cost function stemming from this theory of hospital behavior will be developed and estimated.

4.6.3 Simultaneous Equation Model: Formulation and Identification

A simultaneous equation model of output and factor input determination must make some assumptions regarding the technical relationship between inputs and output (i.e. the production function). A modified Cobb-Douglas function will be assumed in the following model:

\[ Q = A L^\alpha K^\beta \]

Production Function

where \( Q \) is quantity of hospital services, \( L \) is labor, and \( K \) is capital.
Although this particular form of the production function is selected primarily because of its tractability, the function may perform well within the observed range of observation. It is unlikely that such a function applies to hospital production in extreme cases. For example, the function could imply that with a small amount of labor, an extremely large amount of output could be produced given sufficient amounts of capital.

From section 4.6.1, the revenue function is

\[ R = B Q^{x_1} Y^\gamma \]

If the hospital maximizes short-run net patient revenue subject to the production function, the following optimal conditions result:

\[
\text{maximize } NR^* = R - wL + \lambda (Q - AL^\gamma K^\beta) \\
= BQ^{x_1} Y^\gamma - wL + \lambda (Q - AL^\gamma K^\beta)
\]

\[
\frac{\Delta NR^*}{\Delta Q} = (\gamma + 1)BQ^{x_1} Y^\gamma + \lambda = 0
\]

so that \( \lambda = (\gamma + 1)BQ^{x_1} Y^\gamma \)

\[
\frac{NR^*}{L} = -w - \lambda \frac{Q}{L} = 0
\]

so that \( w = (\gamma + 1)BQ^{x_1} Y^\gamma Q/L \)

and \( L = \alpha(\gamma + 1)BW^{-1}Y^\gamma Q^{x_1} \)
Labor may be determined by the marginal productivity conditions and output may be determined from the production function (given capital).

By the theoretical model developed in Chapter 3, investment is equal to lagged net revenue:

\[ I_t = K_t - K_{t-1} = NR_{t-1} \]

so that \( K_t = K_{t-1} + NR_{t-1} \).

The structural system is then as follows:

\[
Q = A L^\alpha K^\theta \\
L = \alpha (\gamma + 1) B w^{-1} Y^m Q^y \\
K = K_{t-1} + NR_{t-1}
\]

The system is recursive since \( Q \) and \( L \) do not enter into the determination of capital services. Capital services may then be considered to be a predetermined variable for the subsystem consisting of the production function and labor input determination.

Reduced form of the structural subsystem may be derived as follows:

If depreciation is included at a constant fraction of previous capital, gross investment equal to lagged net revenue implies the following:

\[
I_t = K_t - K_{t-1} + \delta K_{t-1} = NR_{t-1} \\
\text{and} \quad K_t = NR_{t-1} + (1 - \delta) K_{t-1}.
\]
\[ L = \alpha (y+1) B w^{-1} Y^\eta Q^{\mu} \]

Substituting into the production function,

\[ Q = A \left[ \left( (y+1)B L \right)^{\beta} \right] w^{\gamma} Y^\eta K^\xi \]

or \[ Q^{1-\alpha(-\gamma)\eta} = A \left[ \left( (y+1)B L \right)^{\beta} \right] w^{\gamma} Y^\eta K^\xi \]

or \[ Q = D_1 w^1 Y^1 K_1 \]

where \[ D_1 = A^{(1-\alpha(-\gamma)\eta)/(y+1)B} \]

\[ r_1 = -\alpha/(1-\alpha(-\gamma)\eta) \]

\[ s_1 = \alpha\eta/(1-\alpha(-\gamma)\eta) \]

\[ t_1 = \beta/(1-\alpha(-\gamma)\eta) \]

Substituting expression for \( Q \) into marginal productivity condition,

\[ L = \alpha (y+1) B w^{-1} Y^\eta \left( D_1 w^1 Y K^1 \right)^{r_1 s_1 t_1} \]

\[ = D_2 w^2 Y^2 K^2 \]

where \[ D_2 = \alpha (y+1) B D_1^{y+1} \]

\[ r_2 = -1 + r_1(y+1) \]

\[ s_2 = \eta + s_1(y+1) \]

\[ t_2 = t_1(y+1) \].
The final model is then as follows:

**Structural**

\[ Q = A \ L^\alpha \ K^\beta \]
\[ L = \alpha (y+1) B Q^\gamma Y^\eta W^{-1} \]

**Reduced Form**

\[ Q = D_1 w^r Y_1 S_1 T_1 \]
\[ L = D_2 w^r Y_2 S_2 T_2 \]

Both structural equations contain \( Q \) and \( L \). The second equation of the structural model contains two exogenous variables not included in equation one \((w, Y)\) so that equation one is over-identified. The first equation contains one predetermined variable not included in the second equation \((K)\) so that the second equation is exactly identified. Two stage least-squares regression analysis, therefore, can be applied to both structural equations, and consistent estimates of the production function and demand equation parameters may be obtained.

In order to obtain consistent estimates of the short-run cost function, an alternative model will now be derived:

\[ Q = A \ L^\alpha K^\beta \]
\[ L = \alpha (y+1) B W^{-1} Y^\eta Q^\gamma + I \]
\[ C \equiv wL \]
The short-run cost identity may be eliminated from the system by substitution of $C/w$ for $L$ in the first and second equations:

\[ Q = A C^{\alpha} w^{-\sigma} k^{\beta} \]

\[ C = \alpha (\gamma + 1) B \gamma^{\eta} q^{\gamma + 1} \]

or equivalently,

\[ C = A^{-\alpha} Q^{\gamma} w^{-\beta/\delta} k^{\theta/\delta} \]

\[ Q = \left[ \alpha (\gamma + 1) B \right]^{-\frac{1}{\gamma + 1}} C^{\frac{1}{\gamma + 1}} Y^{-\frac{n}{\gamma + 1}} w^{-\frac{\theta}{\delta}} k^{\eta} \]

The reduced form may be derived as follows: substituting second equation into first equation,

\[ C = A^{-\alpha} \left[ \left[ \alpha (\gamma + 1) B \right]^{-\frac{1}{\gamma + 1}} C^{\frac{1}{\gamma + 1}} Y^{-\frac{n}{\gamma + 1}} w^{-\frac{\theta}{\delta}} k^{\eta} \right] \]

or

\[ C^{1 - \frac{1}{\alpha (\gamma + 1)}} = A^{-\alpha} \left[ \left[ \alpha (\gamma + 1) B \right]^{-\frac{1}{\gamma + 1}} w^{-\frac{\theta}{\delta}} k^{\eta} \right] \]

or

\[ C = M \quad w^{\frac{1}{\gamma + 1}} k^{\frac{1}{\gamma + 1}} Y^{\frac{n}{\gamma + 1}} \]

where

\[ M = A^{-\alpha} \left[ \left[ \alpha (\gamma + 1) B \right]^{-\frac{1}{\gamma + 1}} w^{-\frac{\theta}{\delta}} k^{\eta} \right] \gamma^{\alpha (\gamma + 1)/\alpha (\gamma + 1) - 1} \]

\[ l_1 = \alpha (\gamma + 1)/(\alpha (\gamma + 1) - 1) \]

\[ m_1 = -\eta / (\alpha \delta + \alpha - 1) \]

\[ n_1 = -\beta (\gamma + 1)/(\alpha \gamma + \alpha - 1) \]
Substituting expression for $C$ into second structural equation,

$$Q = \left[ \alpha (\gamma + 1) B \right]^{\frac{-1}{\gamma + 1}} (M_1 w^{1_1} y^{m_1} k^{n_1})^{\frac{1}{\gamma + 1}} y^{\frac{-n_1}{\gamma + 1}}$$

or

$$Q = M_2 w^{1_2} y^{m_2} k^{n_2}$$

where $M_2 = M_1^{\frac{1}{\gamma + 1}} \left[ \alpha (\gamma + 1) B \right]^{\frac{-1}{\gamma + 1}}$

$$l_2 = l_1 / (\gamma + 1)$$

$$m_2 = m_1 / (\gamma + 1) - \psi / (\gamma + 1)$$

$$n_2 = n_1 / (\gamma + 1)$$

The alternative model is then as follows:

<table>
<thead>
<tr>
<th>Structural</th>
<th>Reduced Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C = A^{-\alpha} Q Y w K^{-B/\alpha}$</td>
<td>$C = M_1 w^{1_1} Y^{m_1} K^{n_1}$</td>
</tr>
<tr>
<td>$Q = \left[ \alpha (\gamma + 1) B \right]^{\frac{-1}{\gamma + 1}} C^{\frac{1}{\gamma + 1}} Y^{-\frac{n_1}{\gamma + 1}}$</td>
<td>$Q = M_2 w^{1_2} y^{m_2} k^{n_2}$</td>
</tr>
</tbody>
</table>

Both structural equations contain $Q$ and $C$. The second equation contains one exogenous variable not contained in the first equation ($Y$) so that the first equation is exactly identified. The first equation contains two predetermined variables not included in second ($w, K$) so that the second equation is overidentified. Consistent estimates may be obtained using two-stage least-squares.
4.6.4 Data

Two sets of data are used to estimate the simultaneous equation model. The first sample consists of 1963 data on ninety-six non-profit, private hospitals in fifteen major standard metropolitan statistical areas.

One possible source of bias in the results stemming from this sample is the possibility of price interdependence among hospitals. In large metropolitan areas patients may have a choice among hospitals, and this choice may be affected by differences in prices among hospitals. A sample based upon hospitals in isolated geographical areas may yield different results. To check for this possibility, the model is estimated with 1960 data on forty-eight Texas hospitals. Only non-profit, private hospitals in non-major metropolitan areas are included in this sample.

Quantity of hospital services provided by the hospital is measured by average daily census (average number of patients in hospital on any one day). Labor input is measured by number of personnel, and total hospital beds constitute the measure of capital.

Family median income for the standard metropolitan statistical area is used in the first set of data and county median family income is used for the Texas data. A scale variable reflecting the size of the market relevant to the hospital is also included in the demand equation.
4.6.5 Results

Two-stage least-squares estimation of the structural model yielded the following estimates for the standard metropolitan statistical area sample:

\[
\begin{align*}
\log Q &= -0.23 + 0.23 \log L + 0.75 \log K & R^2 &= 0.95 \\
&[-1.59] [3.37] [9.81] \\
\log L &= -2.56 + 1.17 \log Q - 0.24 \log W & R^2 &= 0.84 \\
&[-1.54] [24.4] [-0.33] \\
&+ 0.35 \log Y + 0.07 \log S \\
&[1.56] [1.84]
\end{align*}
\]

In general, the results lend fairly strong support to the model. Overall explanation is high, coefficients enter with the expected signs, and individual variables tend to have fairly high t-scores.

The absolute value of some coefficients is of particular interest. The sum of the labor and capital coefficients in the production function estimation is 0.98 indicating approximately constant returns to scale. The elasticity of output with respect to labor is somewhat lower, and the elasticity of output with respect to capital is somewhat higher, however, than might be expected.

The coefficient of the wage variable enters with a negative sign as predicted. Its absolute value is somewhat less than the 1.0 predicted by the model.
Both the income and the scale variable enter with positive coefficients indicating that areas with higher incomes and few hospital facilities per capita will have higher prices for the same levels of output.

The coefficient of quantity in the labor input determination equation is somewhat unsatisfactory with an estimate of 1.17 rather than between 0 and 1 as expected.

Very similar results were obtained using the Texas hospital data:

\[
\begin{align*}
\log Q &= -1.13 + .35 \log L + .76 \log K \\
& \quad [-4.63] [1.70] [2.98] \\
R^2 &= .94 \\
\log L &= - .72 + 1.04 \log Q + .15 \log Y \\
& \quad [-.74] [22.3] [1.19] \\
& \quad + .06 \log S - .23 \log w \\
& \quad [1.94] [-2.03] \\
R^2 &= .94
\end{align*}
\]

Again, overall explanatory power of the equations is high. The fit of the labor input determination equation is somewhat higher than in the metropolitan statistical estimation. All coefficients enter with the expected sign with generally significant t-scores.

The return to scale parameter is 1.11 which is somewhat higher than the .98 based upon the metropolitan data. To some extent the
finding of slightly increasing returns to scale in the Texas sample and constant returns to scale in the major metropolitan area sample may be attributable to different sized hospitals considered in each sample. In the Texas sample, hospitals range in size from fifty-seven beds to five hundred and seven beds. In the major metropolitan area sample, hospitals range in size from 300 beds to 1,454 beds. It is possible, therefore, that the production function exhibits increasing returns to scale for smaller hospitals and constant returns to scale over larger-sized hospitals.

Individual elasticities of output with respect to labor and to capital are .35 and .76, respectively, again somewhat different from what might be expected.

The coefficient of the wage variable enters with a negative sign as expected and is significantly different from zero. It is somewhat less than the −1.0 predicted, however.

As in the major metropolitan area sample, higher incomes tend to increase the demand for hospital services. Greater population per available hospital facility also increases the price which hospitals can receive for any given level of output.

The coefficient of quantity of hospital services in the labor input determination equation is somewhat lower than in the
metropolitan sample but still exceeds one (1.04). However, it is not significantly different from values less than one so that the hypothesis that the coefficient lies between zero and one cannot be rejected.

Estimation of the alternative simultaneous equation structural system including the structural cost function is given below for the major metropolitan statistical area data:

\[
\log C = 0.68 + 4.40 \log Q - 3.3 \log K + 1.20 \log w \quad R^2 = 0.40
\]

\[
\log Q = 6.02 + 0.83 \log C - 0.73 \log Y - 0.09 \log S \quad R^2 = 0.79
\]

All coefficients enter with the expected signs and all are statistically significant (other than constant term). Overall explanatory power of the equations is somewhat lower, however.

The first equation of the model is the structural cost equation. The coefficient of quantity of services is greater than one indicating that short-run costs (similar to total variable costs) increase more than proportionately with quantity so that the average variable cost is increasing. Increases in capital decrease total variable costs suggesting that capital substitutes for additional labor. As predicted, costs increase with increases in wages. The wage coefficient is insignificantly different from the 1.0 predicted by the model.
Estimation of the cost structural system based upon the Texas hospital data is as follows:

\[
\log C = 1.62 + 1.55 \log Q - .60 \log K + .75 \log w \quad R^2 = .92
\]

\[
\log Q = .22 + .84 \log C - .06 \log Y - .08 \log S \quad R^2 = .90
\]

Again, all coefficients enter with the expected signs. Overall explanatory power of the equations is consistently high. Capital coefficient in the cost equation is not significant, however. Coefficient of income in the second equation is also not significant.

Figures 15 and 16 plot the cost structural equation for the major metropolitan area data and the Texas hospital data, respectively. Various values of capital are assumed, and the wage level is assumed to be that which is average for all hospitals in the sample.

4.6.6 Need for Additional Research

Although estimation of the structural system yielded surprisingly good results, the model could be additionally refined if data on prices of hospital services were available. With price data the demand equation could be entered directly into the structural system rather than using the demand equation to eliminate price. Additional data on insurance coverage might also improve the explanation of the demand equation.
CHAPTER 5

Summary of Findings and Implications for Public Policy

Five major hypotheses concerning the economic behavior of non-profit, private hospitals have been developed and tested in the above chapters: 1) demand for hospital's prices depends upon hospital's capital stock, 2) short-run costs vary with capital stock, 3) prices are set so as to maximize net patient revenue, 4) all net patient revenue and private contributions are invested, and 5) investment funds are allocated among projects so as to maximize future net patient revenue.

5.1 Summary of Findings

Although the evidence concerning the relationship between specialized facilities and demand for hospital services is inconclusive, hospitals in twenty-one major metropolitan areas which acquired various specialized facilities over the period from 1963 to 1966 tended to experience increases in market share while hospitals already possessing facilities tended to experience declines in market share. To the extent that specialized facilities attract doctors to a hospital's staff and increase future demand for all hospital services, hospitals may acquire facilities which
do not generate sufficient revenue from services produced with those facilities to cover cost of facilities. Increased revenue from other services, indirectly induced by acquisition of the facilities, however, would make the facilities a "profitable" investment. Additional evidence is required before the significance of the hospital's extensiveness of specialized facilities on demand for its services can be decisively determined.

Analysis of the hospital's average direct costs revealed that acquisition of specialized facilities increases the cost per patient day of providing hospital services. Ordinary least-squares regression analysis indicated that average direct costs decline with increases in hospital's bed capacity when not accompanied by increases in specialized facilities suggesting some economies of scale in the production of routine services.

Failure to adjust for the effect of capital facilities on average cost leads to estimates of average costs which are too high, particularly for larger hospitals which tend to have more specialized facilities. Before adjusting for the effect of specialized capital equipment, average cost curves shifted upward with increases in the hospital's bed capacity, incorrectly suggesting decreasing returns to scale. Cost curves which are unadjusted for the influence of specialized facilities also suggest the inverted U-shaped envelope cost curve up to the 300 bed size hospital found
in earlier studies. This inverted U-shape disappears after possession of specialized facilities is included as an explanator of average cost. Explanation of this phenomena lies in the fact that average cost estimates of small hospitals (say, less than 150 beds) are virtually the same whether or not specialized facilities are included since few hospitals in this size range have many specialized facilities. Average cost of hospitals in the 150 to 300 bed size range, however, are shifted significantly downward by separating out the extra costs attributable to the specialized facilities. Overall envelope is, therefore, constant or declining in the smaller hospital range, rather than an inverted U-shape.

Even though the minimum point of the average direct cost curves tend to fall throughout most of the range observed, hospitals which expand bed capacity without enjoying an increase in the demand for its services may find its net revenue declining. Consider Figure 17. As the hospital expands bed capacity, the minimum point of the average direct cost curves shifts downward. With fixed demand, however, eventually the hospital will experience considerable excess capacity and short-run average direct costs at optimal levels of output will be higher than for smaller facilities. For example, in Figure 17 if hospital expands to size corresponding to SRADC₃, optimal quantity of output is Q₃ (determined by MR=SRMC₃) and price=SRADC₃ so that net patient revenue is reduced to zero.
FIGURE 17
The hospital could be making positive net revenue if it were at the smaller size hospital corresponding to SRADC₂.

Given the cost structure estimated in Chapter 4 in which short-run average direct costs for larger hospitals lie above short-run average costs for smaller hospitals for at least some levels of output, increasing size of hospital will drive net revenue to zero in cases of stagnant demand for services.

Section 4.3 tested the commonly held view that hospitals equate prices of services to average cost of providing services. In a fifty state cross-section study, price-cost ratios were found to vary significantly with per capita income. In states with higher per capita incomes, prices were a higher percentage of average costs than in states with lower per capita incomes. Also areas which provided alternatives to private hospital care in the form of city, county or state hospitals had lower markups over cost embodied in the prices of private hospital services suggesting that governmental hospital care imposes a competitive influence on behavior of private hospitals. Inability to obtain appropriate data on insurance coverage prevented investigating in detail the effect of insurance coverage on price charged for private hospital services in relation to the average cost of providing services.

Two avenues for future research on the relationship between prices and average costs might yield interesting additional
information. First, structural characteristics of the market for hospital services such as the concentration of provision of an area's hospital services in a few hospitals might also be found to influence the price-cost ratios if data could be broken down into appropriate geographical areas. Second, if additional data on prices and outputs of ancillary services should become available, differences in price-cost ratios of various services produced by hospital could be analyzed.

Scarcity of capital data prevented detailed empirical analysis of hospital's investment decisions. In order to test the hypothesis that hospitals invest all net patient revenue and external funds in additions to plant and equipment, it was necessary to approximate source of funds by total revenue in excess of payroll expenses. Correlation coefficient analysis of the relationship between one year's investment in plant and equipment and previous year's proxy for net revenue yielded a statistically significant relationship for all years between 1960 and 1966.

Absence of detailed data on investment in specialized equipment and facilities made it impossible to test adequately the hypothesis that hospitals allocate funds among alternative investment projects so as to maximize future net patient revenue. Even though total investment in plant and equipment was found to
be highly correlated with lagged net revenue, analysis of investment in additional bed capacity revealed that hospitals tend to invest in bed capacity only when operating at a high level of capacity. As shown above in Table 14, hospitals with an occupancy rate between 90 and 100 percent of capacity at the beginning of the period increased bed capacity by 15.3 percent over the period (1963–1966) while hospitals operating at less than sixty percent of capacity actually contracted bed capacity by .1 per cent. The evidence indicates, therefore, that although hospitals invest all funds acquired, investment in bed capacity is undertaken only if additional capacity is "required" (i.e. the capacity constraint is binding).

Simultaneous equation estimation of output and factor input determination demonstrated that hospital production may be closely characterized by the Cobb–Douglas production function. In a sample of hospitals ranging in size from 57 to 507 beds, the Cobb–Douglas production function evidenced slightly increasing returns to scale. In a sample of hospitals ranging in size from 300 to 1454 beds, the Cobb–Douglas production function indicated constant returns to scale. The long-run average cost curve which may be inferred from estimation of the production function is L-shaped.

The hypothesis that hospitals determined labor input so as to maximize short-run net revenue was also substantiated by
the empirical results. Overall explanation of the labor input
determination equation was .84 in the sample based on hospitals
in large metropolitan areas and .94 in the sample based on hospitals
in isolated geographical areas. All variables entered with
expected signs.

Future research could additionally refine estimation of
the simultaneous equation system if data on individual hospital
prices should become available. Demand equation could then be
included separately into the model. Data on insurance coverage
might also improve overall explanatory power of the model.

Reformulating the simultaneous equation system to include
the structural cost equation allowed estimation of the short-run
direct costs of providing hospital care. Increases in capital
stock were found to decrease average direct costs. Restricted
functional form, however, prevented short-run average direct
cost curves from taking on U-shapes found in earlier ordinary
least-squares estimation of the short-run average direct cost
curves.

5.2 Implications for Public Policy

The findings of this study strongly suggest that hospitals
are not institutions strictly concerned with serving the public and
providing services at cost. Instead hospitals attempt to maximize net patient revenue which is plowed back into additional investment in hospital capacity and specialized equipment and facilities.

Special treatment of hospitals as non-profit organizations should be re-examined. Hospitals in an area should not be permitted to collude and establish price-fixing arrangements which keep prices to the public higher than would otherwise be the case.

Since establishment of city or county charity hospitals tends to keep prices in private hospitals lower than they would otherwise be, local governments, where feasible, should consider establishing own hospitals rather than reimbursing private hospitals for care of indigent patients.

As long as funds for investment are available, private hospitals will acquire specialized facilities even if the effect of acquisition is to raise average costs of providing services in the future. Excessive capitalization can be expected if private hospitals are allowed to make their own investment decisions.

On the other hand, small hospitals which have not exploited available economies of scale in the provision of hospital services may not be inclined to borrow the funds necessary to achieve optimal size. Adjustment to optimal size may be quite slow. Governmental policies aimed at increasing size of inefficient sized hospitals should reduce average costs of providing care.
One of the most important implications of the findings regarding hospital behavior lies in the reaction of private hospitals to third-party reimbursement schemes. According to the theoretical model developed in Chapter 3, Medicare could be expected to increase the price charged private patients and increase hospital revenue. Initial experience with Medicare indicates that this has happened. Reimbursing hospitals on the basis of cost for a given segment of society increases prices charged other segments of society. Reimbursement on the basis of charges would have the same effect. In addition schemes such as Medicare which base reimbursement on the basis of prices charged for various services produced by hospital tend to distort internal rate structures.

One possible alternative to the existing system which would remove these defects would be rate regulation of hospital services. Patients could be charged the relatively low short-run marginal cost of services. Governmental agencies could reimburse hospitals for the excess of short-run average direct costs over marginal cost paid by the patient. Provision of all capital facilities and equipment could be financed and controlled by governmental agencies. In this way excessive capitalization could be prevented and charges to patients would be within the financial capability of most members of society.

The above is only one possible suggestion out of the dilemma posed by the behavior of private hospitals and their reaction to third-party reimbursement schemes. Additional research of the impact of this scheme as well as other alternatives within the context of the behavioral model developed in this study is required.
APPENDIX A

Output Maximization

The output maximization model of Section 2.2.2 may be generalized to the case of n goods with interdependent demands as follows: let $x_1$ be the number of private room days produced by the hospital, $x_2$ be the number of semi-private room days, and $x_3$, ..., $x_n$ be quantities of various ancillary services such as X-rays and laboratory tests. It will be assumed that net prices of private and semi-private rooms influence the hospitalization decision and length of stay after hospitalized, but that net prices of ancillary services do not. The demand for ancillary services, however, will depend not only on the net prices of ancillary services, but on room rates as well inasmuch as high room rates may cause individuals to forego hospitalization and accompanying ancillary services provided by the hospital.

Demand for services produced by the hospital, therefore, may be represented as follows:

$$x_1 = x_1(p_1, p_2)$$
$$x_2 = x_2(p_1, p_2)$$
$$x_3 = x_3(p_1, p_2, p_3)$$
$$x_n = x_n(p_1, p_2, p_n)$$
where \( p_1 \) is price charged by hospital for private rooms, \( p_2 \) is price charged by hospital for semi-private rooms, and \( p_j \) is price charged by hospital for ancillary service (\( j = 3, \ldots, n \)).

Let \( C(x_1, \ldots, x_n) \) equal total cost of producing all hospital services.

Then, maximizing number of patients served subject to the financial constraint of breaking even yields the following:

Maximize \( L^* = x_1 + x_2 + \lambda (p_1 x_1 + \ldots + p_n x_n - C(x_1, \ldots, x_n)) \)

\[
\frac{\partial L^*}{\partial p_1} = \frac{\partial x_1}{\partial p_1} + \frac{\partial x_2}{\partial p_1} + \lambda (x_1 + p_1 \frac{\partial x_1}{\partial p_1} + \ldots + p_n \frac{\partial x_n}{\partial p_1}) - \left( \frac{\partial C}{\partial x_1} \frac{\partial x_1}{\partial p_1} + \ldots + \frac{\partial C}{\partial x_n} \frac{\partial x_n}{\partial p_1} \right) = 0.
\]

\[
\frac{\partial L^*}{\partial p_2} = \frac{\partial x_1}{\partial p_2} + \frac{\partial x_2}{\partial p_2} + \lambda (x_2 + p_1 \frac{\partial x_1}{\partial p_2} + \ldots + p_n \frac{\partial x_n}{\partial p_2}) - \left( \frac{\partial C}{\partial x_1} \frac{\partial x_1}{\partial p_2} + \ldots + \frac{\partial C}{\partial x_n} \frac{\partial x_n}{\partial p_2} \right) = 0.
\]

\[
\frac{\partial L^*}{\partial p_3} = \lambda (x_3 + p_3 \frac{\partial x_3}{\partial p_3} - \frac{\partial C}{\partial x_3} \frac{\partial x_3}{\partial p_3}) = 0.
\]

\[
\vdots
\]

\[
\frac{\partial L^*}{\partial p_n} = \lambda (x_n + p_n \frac{\partial x_n}{\partial p_n} - \frac{\partial C}{\partial x_n} \frac{\partial x_n}{\partial p_n}) = 0.
\]
\[
\frac{\partial L^*}{\partial \lambda} = p_1 x_1 + \ldots + p_n x_n - C(x_1, \ldots, x_n) = 0.
\]

In the special case where \(\left| \frac{\partial x_1}{\partial p_1} \right| = \left| \frac{\partial x_2}{\partial p_1} \right|\) for all feasible \(p_1\), (i.e. an increase in private room charge increases semi-private patients by same amount that it decreases private patients), then marginal revenue of private rooms is equated to marginal cost of private rooms. Also, marginal revenue equals marginal cost for all ancillary services so that price of semi-private rooms is set at a level such that total revenue on semi-private rooms equals total costs of providing all services less total revenue on all other services:

\[
p_1 x_1 + \ldots + p_n x_n - C(x_1, \ldots, x_n) = 0
\]

which implies

\[
p_2 x_2 = C(x_1, \ldots, x_n) - \sum_{i \neq 1} p_i x_i
\]

All revenue on private rooms and ancillary services is used to subsidize losses on semi-private rooms.

In the more general case, marginal revenue is equated to marginal cost for all ancillary services. The excess of cost over ancillary service revenue is proportioned between private and semi-private rooms as follows:

\[
\frac{\frac{\partial x_1}{\partial p_1}}{\frac{\partial x_2}{\partial p_1}} + \frac{\frac{\partial x_2}{\partial p_2}}{\frac{\partial x_2}{\partial p_2}} = \frac{MR_1 - MC_1}{MR_2 - MC_2}
\]
APPENDIX B

Utility Maximization

The utility maximization model of section 2.2.3 now will be generalized to include more than one type of output and more than one type of capital. In addition, demand for output will be depicted as dependent upon the hospital's capital.

In Section 3.1.1 above, it has been argued that demand for a hospital's services depend upon the number of doctors on the hospital's staff. In turn, the number of doctors which will affiliate with a given hospital depends upon the extensiveness of the hospital's capital equipment. Demand for services produced by the hospital, therefore, may be represented as follows:

\[ p_1 = p_1(x_1, K_2) \]

\[ p_2 = p_2(x_1, x_2, K_2) \]

where \( p_1 \) is price of room services, \( p_2 \) is price of ancillary services, \( x_1 \) is quantity of room services provided, \( x_2 \) is quantity of ancillary services provided, and \( K_2 \) is specialized capital equipment.

In deriving the implications of utility maximization for hospital output and capital determination, it will be assumed that \( x_1 \) and \( x_2 \) are produced independently so that the production functions
are \( x_1 = F_1(K_1, L_1) \) and \( x_2 = F_2(K_2, L_2) \) where \( L_1 \) is labor used to produce room services, \( L_2 \) is labor used to produce ancillary services, and \( K_1 \) is hospital's plant capital (bed facility). As defined, \( K_1 \) and \( K_2 \) correspond roughly to the types of capital required in the production of room services and ancillary services, respectively, only one type of capital is included in each production function. This could easily be extended to the more general case.

Maximizing the utility function subject to the financial constraint of zero total profits and technological constraints of the production function yields the following:

Maximize \( U^* = U(x_1, x_2, K_1, K_2) + \lambda(p_1(x_1, K_2)x_1 + p_2(x_2, x_1, K_2)x_2 - w_1 L_1 - w_2 L_2 - r_1 K_1 - r_2 K_2) + \mu_1(F_1(K_1, L_1) - x_1) + \mu_2(F_2(K_2, L_2) - x_2) \)

\[
\begin{align*}
(1) \quad \frac{\partial U^*}{\partial x_1} &= \frac{\partial U}{\partial x_1} + \lambda(p_1 + x_1 \frac{\partial p_1}{\partial x_1} + x_2 \frac{\partial p_2}{\partial x_2}) - \mu_1 = 0. \\
(2) \quad \frac{\partial U^*}{\partial x_2} &= \frac{\partial U}{\partial x_2} + \lambda(p_2 + x_2 \frac{\partial p_2}{\partial x_2}) - \mu_2 = 0. \\
(3) \quad \frac{\partial U^*}{\partial L_1} &= -\lambda w_1 + \mu_1 \frac{\partial F_1}{\partial L_1} = 0. \\
(4) \quad \frac{\partial U^*}{\partial L_2} &= -\lambda w_2 + \mu_2 \frac{\partial F_2}{\partial L_2} = 0. \\
(5) \quad \frac{\partial U^*}{\partial K_1} &= \frac{\partial U}{\partial K_1} - \lambda r_1 + \mu_1 \frac{\partial F_1}{\partial K_1} = 0. \\
(6) \quad \frac{\partial U^*}{\partial K_2} &= \frac{\partial U}{\partial K_2} - \lambda r_2 + \lambda(x_1 \frac{\partial p_1}{\partial K_2} + x_2 \frac{\partial p_2}{\partial K_2}) + \mu_2 \frac{\partial F}{\partial K_2} = 0.
\end{align*}
\]
(7) \[ \frac{hU^*}{\delta \lambda} = p_1x_1 + p_2x_2 - w_1L_1 - w_2L_2 - r_1K_1 - r_2K_2 = 0. \]

(8) \[ \frac{\partial U^*}{\partial \mu_1} = F_1(K_1, L_1) - x_1 = 0. \]

(9) \[ \frac{\partial U^*}{\partial \mu_2} = F_2(K_2, L_2) - x_2 = 0. \]

From (3) and (4), \( \mu_1 = \frac{\lambda w_1}{\delta F_1/\delta L_1} \) and \( \mu_2 = \frac{\lambda w_2}{\delta F_2/\delta L_2} \).

Therefore,

\[ \frac{\partial U}{\partial x_1} = -\lambda (MR_1 + x_2 \frac{\partial p_2}{\partial x_1} - w_1 \frac{\partial F_1}{\partial L_1} ) \]

\[ \frac{\partial U}{\partial x_2} = -\lambda (MR_2 - \frac{w_2}{\partial F_2/\partial L_2} ) \]

\[ \frac{\partial U}{\partial k_1} = \lambda (r_1 + w_1 \frac{dL_1}{dk_1} ) \]

\[ \frac{\partial U}{\partial k_2} = \lambda (r_2 - x_1 \frac{\partial p_1}{\partial k_2} - x_2 \frac{\partial p_2}{\partial k_2} + w_2 \frac{dL_2}{dk_2} ) \]

and

\[ \frac{\delta U}{\delta x_1} \frac{w_1}{\delta F_1/\delta L_1} - MR_1 - x_2 \frac{\delta p_2}{\delta x_1} = \frac{\delta U}{\delta x_2} \frac{w_2}{\delta F_2/\delta L_2} - MR_2 = \frac{\delta U}{\delta k_1} \frac{r_1 + w_1 \frac{dL_1}{dk_1}}{r_2 - x_1 \frac{\delta p_1}{\delta k_2} - x_2 \frac{\delta p_2}{\delta k_2} + w_2 \frac{dL_2}{2dk_2}}. \]
Again, the equilibrium conditions may be interpreted as equating the marginal utility of each output per extra dollar cost of another unit of each output with the marginal utility of each type of capital per extra dollar cost of another unit of each type of capital. Unlike the simple model, the extra dollar cost of another unit of room services ($x_1$) depends upon the effect of changes in the price of room services upon the demand for ancillary services ($x_2$) so that the extra dollar cost of another unit of room services includes the term $x_2 \frac{\partial P_2}{\partial x_1}$. The extra dollar cost of another unit of specialized capital equipment also includes terms to reflect the impact of additional capital equipment on the demand for room services and the demand for ancillary services.
APPENDIX C

A Review of Empirical Hospital Cost Studies

C.1 P. Feldstein

P. Feldstein was the first economist to apply statistical techniques to estimation of the long-run cost curves of hospitals. His estimation was based on data for sixty hospitals ranging in size from 48 to 453 beds. He obtained the following estimation of the long-run total cost curve:

\[ TE = 267,692 + 22.86 \times PD^{2} \]

\[ R^{2} = .85 \]

(1.28)

where TE is total operating expenses and PD is patient-days. Standard error is shown in parentheses.

Feldstein does not indicate whether additional terms in \( PD^{2} \), \( PD^{3} \), etc. were tried to see if they significantly increase the explanatory power of the equation. The functional form shown above, of course, shows long-run marginal costs to be constant and long-run average costs to be falling over the range of observations.

Feldstein recognizes the possibility that larger hospitals may provide a larger number of services. Failure to adjust for

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this may give a large upward bias to the results.

While Feldstein's study represents an important improvement in the analysis of hospital costs, several weaknesses should be noted. First, estimating the total cost curve instead of the average cost curve suggests the likelihood of heteroscedasticity leading to a biased estimate of the standard errors of the coefficients. No test of homoscedasticity is given, and the data on which such a test could be made are not published. Second, as Feldstein recognizes, neglect of the effect of specialized facilities and services may impart substantial bias to the results. Third, no adjustment is made for differences in factor costs. No information is supplied on the extent of geographical dispersion of the sample or how the sample was selected so that no judgment can be made on the validity of the implicit assumption that all hospitals face the same factor costs. If hospitals in the sample are located closely together, wage rates and other factor costs may be the same for all hospitals.

C.2 Berry

Berry's study attempts to account for the effect of specialized facilities on hospital costs. His method of analysis

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is to form forty groups of hospitals with all hospitals in a
given group having the same facilities. Average total costs are
regressed on patient days. The coefficient of patient–days is
found to be negative in 36 out of 40 cases. Berry concludes that
his results provide overwhelming support for evidence of economies
of scale.

Several comments are in order. 1) Of the forty regressions
only five of the patient–days coefficients are significantly
negative at the 5 percent level and only one additional coefficient
is significantly negative at the 10 percent level. By standard
tests of significance, the case for economies of scale is not strong.
2) If all hospitals within any one group are of roughly the same
size, Berry's regression would be estimating the short–run average
cost curve for that size hospital. To the extent that groups are
homogeneous with respect to bed capacity as well as facilities,
his estimates should reflect the existence of short–run falling
or constant costs rather than long–run economies of scale. If
hospitals within a group are not homogeneous with respect to size,
observed points are likely to be points off various short–run cost
curves giving no obvious meaning to the estimated curve. 3) Berry's
sample is drawn from non–federal, short–term, general hospitals
throughout the U.S. so his failure to adjust costs for differences
in wages and prices of other factor inputs is likely to impart
substantial bias to his results.
The importance of adjusting cost data for variations in labor costs is recognized in a study of hospital cost variation by Cohen. He adjusts total operating costs for differences in starting salaries among hospitals, and he also makes an indirect attempt to incorporate the effects of specialized facilities by developing a new measure of hospital output.

His data on 53 hospitals in a six-state northeastern region are drawn from questionnaire responses. Since he obtains a significantly negative constant term when regressing total costs adjusted for wage differences on patient-days, he develops an alternative measure of output. Output is defined as patient days plus a weighted average of various ancillary service outputs where the weights are the ratio of ancillary service average cost to routine service average cost. Using this measure of output he obtains the following result:

\[ T_{\text{adj}} = 88.803 + 1.9Q_{\text{adj}} + 0.00001Q_{\text{adj}}^2 \]
\[ R^2 = 0.97 \]

The average cost curve is U-shaped with a minimum at about 160–170 beds.

The adjusted measure of output was also used in a study of 23 New York area hospitals. For 1962, a negative constant term was found. In 1963–1964, a U-shaped average cost curve with

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minimum at 290-295 beds was found as follows:

\[ TC = 499,446 + 17 Q_{adj} + 0.00002 Q_{adj}^2 \quad R^2 = .99 \]

Standard errors are shown in parentheses.

The principal weakness of Cohen's study is the particular method used to adjust for the effect of specialized facilities. Since data on specialized services were directly available, outputs of various specialized services could have been entered directly into the regression as "explanators" of total cost. By using relative cost of ancillary services as weights in his output measure, the regression is almost reduced to a tautology. This may be seen most easily, perhaps, by a simple mathematical exposition.

By definition, \( Q_{adj} = PD + S_1(AC_1/AC_{PD}) + \ldots + S_n(AC_n/AC_{PD}) \)

and \( TC = PD'AC_{PD} + S_1AC_1 + \ldots + S_nAC_n \) where \( PD \) is patient-days, \( AC_i \) is average cost of ith ancillary service, \( AC_{PD} \) is average cost of inpatient day, \( S_i \) is quantity of ith ancillary service.

Therefore, \( TC = Q_{adj} \cdot AC_{PD} \).

Regressing \( TC \) on \( Q_{adj} \) will yield a perfect fit if average cost per patient day is the same for all hospitals. The estimation obtained:

\[ TC = 499,446 + 17 Q_{adj} + 0.00002 Q_{adj}^2 \]
really shows that:

\[ AC_{PD} = 499.446 \frac{1}{Q_{adj}} + 17 + 0.00002 Q_{adj} \]

(264;107) \quad (2.3) (.000006)

since TC = \( Q_{adj} \cdot AC_{PD} \). Since the coefficient of \( 1/Q_{adj} \) is insignificant, the regression indicates that the average cost of providing routine services increases somewhat with adjusted output. What the equation should be estimating, however, is the average cost of providing all services (both routine and ancillary) as a function of adjusted output. The estimate obtained can not even be interpreted as the average cost curve of providing routine services since the measure of output is a mixture of both routine and ancillary services.

It is also unfortunate that Cohen's method of adjusting costs for variations in wages is based on the unrealistic assumption that all hospitals regardless of size and range of specialized facilities have the same employee composition. This is extremely unlikely since hospitals with specialized facilities could be expected to have a greater proportion of highly specialized employees.

Although estimating the total cost curve, rather than the average cost curve, does give Cohen high multiple determination coefficients, his estimates of standard errors are likely to be substantially biased because of heteroscedasticity.
Since Cohen does not stratify his sample into different size groups, his estimate of the average cost curve is subject to the same fundamental criticism that observed points lie on various short-run curves so that one curve fitted through those points is meaningless.

C.4 Carr and P. Feldstein

Carr and Feldstein use two approaches to account for the effect of specialized facilities: 1) inclusion of a variable reflecting the number of facilities and services available and 2) stratification of the sample into groups of hospitals with approximately the same number of specialized facilities. Adjustment for differences in wage cost was made by assuming that the "real" wage cost of a hospital equals average wage rate of all hospitals times number of full-time employees of the hospital.

Results obtained are as follows:

\[
ATC = -307,568 + 34.70 PD + 0.300351 PD^2 + 33,827 S \\
\quad -0.31 S \cdot PD + 23,188 NS - 1805 N + 5034 IR + 55,347 IRP \\
\quad + 4.81 OPV + 174,790 MS \\
\quad (1.19) \quad (0.000029) \quad (3.619) \\
\quad (0.07) \quad (21,593) \quad (295) \quad (617) \quad (5,480) \\
\quad (0.34) \quad (43,744) 
\]

\[R^2 = 0.947\]

\[4\]

where ATC is average total cost, PD is patient-days, S is number of facilities and services available, NS is existence of hospital-controlled professional nursing school, N is number of student nurses, IR is number of interns and residents, IRP is number of types of internship and residency programs offered, OPV is number of outpatient visits, and MS is affiliation with a medical school. Estimation was based upon data from 3,147 hospitals. Standard errors of coefficients are shown in parentheses.

The data were then stratified into five groups: hospitals with 0–9 facilities and services, 10–12 facilities and services, 13–16 facilities and services, 17–19 facilities and services, and 20–28 facilities and services. The estimated average cost per patient day as a function of average daily census obtained for the various groups is shown in Figure 18. Average cost curves are U-shaped shifting upward through the fourth group of hospitals (17–19 facilities and approximately 100 beds), and then shifting downward.

Both the attempt to adjust for the effect of specialized facilities and wage differences have some weaknesses. The adjustment for wage differences is subject to the same criticism as Cohen's study. Hospitals with more specialized services can be expected to have relatively more technical personnel so that the wage rate of their employees will be higher than other hospitals even if all hospitals must pay the same scale of wages for various employee classifications.
Stratification of hospitals into groups with same number of facilities is only meaningful if hospitals within a group have same type of facilities. As shown in Figure 18, hospitals within a group tend to be homogeneous with respect to size so that estimated curves may reflect short-run cost curves for various size plants.

It would be desirable, however, to know not only what the costs of hospital care are for hospitals with given size and facilities but what the costs would be if hospitals were of that given size but did not possess various specialized facilities. Cost curves adjusted for the effect of specialized facilities would then reflect the cost of providing routine services.

C.5 M. Feldstein

In an empirical study of the British hospital system, M. Feldstein overcomes many of the problems plaguing earlier hospital cost studies. Since hospital wages are uniform throughout England, actual cost data may be used without serious danger of introducing bias due to differences in prices of factor inputs. Higher costs attributed to specialized facilities are accounted for indirectly by introducing as explanatory variables the proportion of a

hospital's patients which fall in a particular case type. For example, if a hospital has higher costs because it has specialized equipment for treating neurosurgery patients, then it is likely that a higher proportion of its patients will be neurosurgery patients. Including the proportion of neurosurgical patients as an explanatory of hospital costs serves as a proxy for neurosurgical specialized equipment.

Feldstein also stratifies his sample of 177 hospitals into four size groups and estimates cost curves separately for each group. Rather than using census or number of cases as an explanatory variable, Feldstein includes both bed capacity and capacity utilization (case-flow rate).

Results for four size groups are as follows:

<table>
<thead>
<tr>
<th>Bed Size</th>
<th>AC equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>72–117</td>
<td>$AC = 4.87 B - 2.58 B^2 + aF + bF^2 + \sum_{i} c_i p_i$</td>
</tr>
<tr>
<td></td>
<td>(2.46) (1.21)</td>
</tr>
<tr>
<td>118–302</td>
<td>$AC = -.07 B - 5.63 B^2 + aF + bF^2 + \sum_{i} c_i p_i$</td>
</tr>
<tr>
<td></td>
<td>(12.02) (28.62)</td>
</tr>
<tr>
<td>303–488</td>
<td>$AC = -4.49 B + 6.41 B^2 + aF + bF^2 + \sum_{i} c_i p_i$</td>
</tr>
<tr>
<td></td>
<td>(54.4) (71.33)</td>
</tr>
<tr>
<td>489–1064</td>
<td>$AC = -1.49 B + 7.51 B^2 + aF + bF^2 + \sum_{i} c_i p_i$</td>
</tr>
<tr>
<td></td>
<td>(1.24) (8.10)</td>
</tr>
</tbody>
</table>
where AC is average cost, B is beds, F is case-flow rate (capacity utilization), $p_i$ is proportion of cases of $i$th type. Estimates of coefficients for case-flow variables and case proportion variables are not given.

In the first size group (72-117 beds), average costs reach a maximum at 96 beds. In the second and third size groups, average costs decline throughout the range. In the largest size group (489-1064 beds), average costs reach a minimum at 1985 beds.

Estimates of the coefficients are in general not significant. This may have been due to high collinearity between $F$, $F^2$, $B$, and $B^2$ over the narrow range of values.
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