# AN ANALYSIS OF THE EFFECTS OF COMPETITIVE MARKETS ON HOSPITAL COSTS IN OKLAHOMA

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TABLE OF CONTENTS

Chapter Page

I. INTRODUCTION . . . . . . . . . . . . . . . . . . 1

Relevance and Purpose of the Study . . . . 1
Plan and Scope of the Study . . . . . . . . 2

II. THE THEORETICAL FRAMEWORK FOR THE STUDY . . . . 4

Introduction . . . . . . . . . . . . . . 4
The Production of Medical Care . . . . . . 5
Physicians as Customers of Hospitals . . . 6
Hospital Cost Behavior: Its Measurement and Causes . . . . . . . . . 10
The Structure of Markets for Hospital Care and the Market Performance of Hospitals . . . . . . . . . . . . . . . 14
The Role of Insurance in the Demand for Medical Care . . . . . . . . . . . . 21
Profit and Property Right Incentives . . . 29
Differential Behavior of For-Profit Versus Nonprofit Hospitals . . . . . . . . 34
Summary . . . . . . . . . . . . . . . . . 36

III. THE ANALYTICAL MODEL: DATA, THEORY, AND SYNTHESIS . . . . . . . . . . . . . . . . . . 37

Introduction . . . . . . . . . . . . . . . 37
Sources of the Data . . . . . . . . . . . . 37
Formulation of the Analytical Model . . . . 41
Hospitals Included in the Set of Observations . . . . . . . . . . . . . . 51
Specification of the Analytical Model . . . 52
Summary . . . . . . . . . . . . . . . . . 54

IV. THE METHODOLOGIES OF ANALYSIS . . . . . . . . . . 55

Introduction . . . . . . . . . . . . . . . 55
Regression Analysis and Computer Methods . . . . . . . . . . . . . . . . 56
Test for Interaction . . . . . . . . . . . 60
Evaluation of Sequential Methods . . . . . 62
Factor Analysis and the Determinants of Average Cost . . . . . . . . . . . . 63
Summary . . . . . . . . . . . . . . . . . 65

Chapter | Page


V. EMPIRICAL RESULTS . . . . . . . . . . . . . . . . 66

Introduction . . . . . . . . . . . . . . . . 66
Some Theoretical Expectations . . . . . . . . 67
Multiple Regression Results: Forty-Eight Independent Variables . . . . . . . . 70
Sequential Model Construction Results: "Forward Selection" and "Stepwise" Procedures . . . . . . . . . . . . . . . 75
Sequential Model Construction Results: The "Maximum $R^2$ Improvement" Technique . . . . . . . . . . . . . . . 83
Regression Results: Tests for Interactions . . . . . . . . . . . . . . 89
Results of a Factor Analysis of the Determinants of Average Cost . . . . . . . 99
Summary . . . . . . . . . . . . . . . . . . 102

VI. SUMMARY OF FINDINGS, CONCLUSIONS, AND IMPLICATIONS . . . . . . . . . . . . . . . . . 104

Introduction . . . . . . . . . . . . . . . . 104
Summary and Conclusions . . . . . . . . . . . 104
Implications of the Study . . . . . . . . . 114

BIBLIOGRAPHY . . . . . . . . . . . . . . . . . . . . 118

APPENDIX . . . . . . . . . . . . . . . . . . . . . . 123

## LIST OF TABLES


| Table | | Page |
|---|---|---|
| I. | Matrix of Correlation Coefficients: Test for Collinear Data | 49 |
| II. | Expected Signs of Regression Coefficients | 68 |
| III. | Regression Results: All Forty-Eight Independent Variables | 71 |
| IV. | Regression Results: Forward Selection and Stepwise Regression Procedures for Dependent Variable CPAD | 76 |
| V. | Regression Results: Forward Selection and Stepwise Procedures for Dependent Variable CPPD | 80 |
| VI. | Regression Results: Maximum $R^2$ Improvement Technique | 84 |
| VII. | Regression Results: Tests for Interactions, Forward Selection and Stepwise Procedures for Dependent Variable CPAD | 90 |
| VIII. | Regression Results: Tests for Interactions, Maximum $R^2$ Improvement Procedure for Dependent Variable CPAD | 92 |
| IX. | Regression Results: Tests for Interactions, Forward Selection and Stepwise Procedures for Dependent Variable CPPD | 95 |
| X. | Regression Results: Tests for Interactions, Maximum $R^2$ Improvement Procedure for Dependent Variable CPPD | 97 |
| XI. | Results of a Factor Analysis of the Determinants of Average Cost | 100 |

## LIST OF FIGURES

Figure Page

1. The Effects of Hospitalization Insurance . . . . . 24

# CHAPTER I

# INTRODUCTION

## Relevance and Purpose of the Study

The cost of hospital care has become an item of intense interest to both producers and consumers of this amalgam of goods and services. Of special interest (and distress) to consumers has been the rather substantial inflation in hospital costs in recent years.[1] If the term "inflation" can be applied to nonmonetary phenomena, there has been a rather substantial "inflation" in the economic literature regarding hospital costs and the mechanisms that cause inflation in this industry. Investigations of the demand for and the cost of hospital care and other medical inputs "filled a number of professional journals and provided grist for the mills of a large number of graduate students in the process of grinding out Ph.D. dissertations."[2] In spite of such literary

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[1]While prices may or may not be representative of "costs" in the medical care industry, an inspection of the August, 1973, issue of the Monthly Labor Review shows that price index calculations place hospital room charges at 181.4 percent of the 1967 base price. The index further reveals that medical care prices in general are only 137.0 percent of 1967 levels against the index for all consumer goods and services of 132.4 percent of 1967 base.

[2]Ryland A. Taylor, "Principles of the Economic Behavior of Hospitals," Nebraska Journal of Economics and Business, XI (Spring, 1972), p. 45.

inflation, little if any of this literature deals with the subject of this dissertation, the effect of competition on hospital costs.

The purpose of this study is to test the hypothesis: "More intense competition in the hospital industry results in higher, rather than lower average costs." The usual assumption that competition among sellers results in lower costs cannot be applied uncritically to the hospital industry. It is shown below that the customs and institutions peculiar to the medical care industry's production and distribution processes have led to some confused and possibly incorrect conclusions regarding the market performance of this industry and its components.

## Plan and Scope of the Study

The second chapter of the study includes an examination of the literature that is relevant to the purposes of the study. The chapter draws on that literature to develop the theoretical framework for the study and introduces the set of assumptions from which the study's analysis proceeds. The third chapter introduces the "model" that is employed in the empirical analysis of the data. The formulation of the appropriate variables and the statement of the analytical model dominates this chapter. The fourth chapter discusses the statistical and other techniques that are the "methodology of analysis" in the study. The fifth chapter presents the results of the empirical analysis. There are included the results of several alternative approaches to the statistical problems involved. The sixth and concluding chapter of the study discusses the implications of the analytical results and compares them with the hypothesis and the purpose of the study.

The scope of the study is subject to a budget constraint and is, therefore, restricted to an examination of the hospital industry in the state of Oklahoma. Consequently, the results of this study cannot be uncritically abstracted to the nation as a whole or even to other states. Nevertheless, it is desirable that these results be subjected to tests for verification or refutation by other investigators or by this writer as is customary in economics and in other scholarly disciplines.

## CHAPTER II

## THE THEORETICAL FRAMEWORK FOR THE STUDY

### Introduction

This chapter presents a brief review of the literature pertaining to the central hypothesis of this study and outlines the theoretical foundations from which the analysis can proceed. First, there is a discussion of the production processes involved in the medical care industry. Then, the viewpoint is developed that the physician, rather than the patient, is the "buyer" or demander of hospital services. There is included some discussion of the expected response of hospitals to their physician-customers. The third section reviews the literature that speaks to the measurement of hospital cost behavior and to the determination of its causes. The fourth section explores those writings that bear directly on the study's hypothesis that more intense competition results in higher average costs: the structure of markets in which hospitals produce and the behavior of hospitals in those different market structures. In the fifth section, the role of insurance in the demand for medical care is explored. The economic behavior of a consumer with and without insurance coverage of hospital expenses is considered. Finally, there is a discussion of the implications of the presence or absence of the profit or property rights incentive as such situations might apply to the main focus of this study.

This chapter is not intended to be an exhaustive exploration of the writings that might be classified under the heading of any one of the sections of the chapter. Rather, it is intended to be a review of those writings and the development of those areas of economic theory that clearly address the subject matter of this dissertation.

## The Production of Medical Care

It is quite difficult to conceptualize the amalgam of goods and services often referred to as "medical care" as a "final produced product." Such conceptualization becomes a bit easier if a term is borrowed from the medical profession and used to describe "final produced product." The term is "therapy." A physician organizes his own resources in concert with other medical inputs such as prescribed drugs and hospital care to produce "therapies" for his patient-customers. The usual organization of the American medical care industry places the physician in private practice as the entrepreneur or the relevant firm that directs production. This particular organizational pattern is not general throughout the medical care industry in other countries or even in the United States itself. For example, in Health Maintenance Organizations such as the Kaiser-Permanente Groups, the physician is a *de facto* employee rather than being in private practice.[1] Even in these kinds of organizations, the physician is in the dominant position as to the selection of the mix of medical inputs that is employed to produce therapies for his patients. It is assumed in this study that the more usual organizational pattern prevails, i.e., where the physician is the entrepreneur. This is, in fact, the most reasonable assumption to make for a study limited to hospitals in the state of Oklahoma.

## Physicians as Customers of Hospitals

Hospital care is viewed in this study as an intermediate product used at times in the production of the final good, medical care or "therapy." The physician is viewed as the entrepreneur or, at least, as the "agent" for patients in organizing production. There is little problem in accepting the notion that the physician organizes and selects the various medical goods and services (including hospital care) that might be used to produce medical care or therapies for his patient-customers. There may be, however, some problem associated with the other viewpoint that physicians, rather than their patients, are considered by hospitals to be their customers. The problem arises out of the conventions and institutions surrounding the way hospital charges are usually paid; the patient or his insurance carriers, not his

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[1] Sidney R. Garfield, "The Delivery of Medical Care," Scientific American, CCXXII (April, 1970), pp. 15-23.

physician, pay hospital charges. Uncritical acceptance of this seller-buyer relationship between hospitals and patients may be misleading regarding the economic character of the total transaction.

The actual involvement of the patient in paying for intermediate products should not obscure the economic relationship between the patient and his physician; the patient-customer is buying medical care from the physician-seller and not buying hospital care, drugs, and physician's services separately. It is this dichotomized payments mechanism that has obscured the underlying economics of the total transaction between the patient and the physician.

If this dichotomized payments mechanism existed in, say, the automobile repair industry, a customer might buy automobile repair but make individual payments to the service manager for diagnosis, to the mechanic for labor, and to the parts department for materials. The medical care industry has been likened to the construction industry where the physician might be a general contractor and hospitals, pharmacies, laboratories, and such might be subcontractors. The purchaser might well make a single payment to the general contractor or individual payments to the subcontractors depending on such factors as the financial strength of the general contractor.[2] Physicians may or may not own and control laboratories, X-ray equipment, and other inputs to

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[2]Robert G. Rice, "Analysis of the Hospital as an Economic Organism," Modern Hospital, CVI (April, 1966), p. 90.

the medical care industry as many general contractors may or may not own and control heavy equipment, lumber yards, and other inputs to the construction industry.

The dichotomized payments mechanism where the origin of the demand for hospital care (physicians) is not the same as the origin of payments for hospital care (patients) may be the source of further inefficiency in the allocation of resources to the hospital sector; such dichotomization separates the business organizations of the physicians' practices of medicine from consideration of the costs of alternative medical goods and services mixes in the selection of least-cost combinations in producing therapies.

E. M. Kaitz, in his study of the Massachusetts' hospital industry, did not explicitly state that the physician was the hospital's customer. He did, however, state that the hospital responded to the physician as if he was, indeed, the customer: "In order to maintain the good will of . . . [physicians], the hospital must be prepared to respond to at least some of their demands for facilities and services."[3]

In an early work (1965), H. E. Klarman acknowledged the dominant role played by physicians in selecting and organizing medical inputs for production. "Once the patient decides to seek help, it is the physician who prescribes the other goods and services, such as drugs and hospital care,

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[3]Edward M. Kaitz, Pricing Policy and Cost Behavior in the Hospital Industry (New York, 1968), p. 78.

that should supplement or replace his own services."[4] While this particular work ranged widely over many health-related fields, Klarman did devote considerable effort to an examination of the physician-hospital relationship in the production of medical care.[5]

An early explicit statement of the view that the physician is the hospital's customer is found in a 1966 article by R. G. Rice.[6] Rice viewed hospitals as producers of the product, hospital care

> . . . which is itself an input in the production of the final product for which a true consumer demand exists, and . . . this final product may be described as "medical care" . . . . That the true consumer demand is for "medical care" rather than its components is hardly a novel idea.[7]

Rice pointed out that there were early examples in the history of the medical care industry in this country where the physician actually purchased hospital services for use in his private practice of medicine.[8] While Rice's intent was not to establish that the physician was the hospital's *de facto* customer, this was a significant conclusion as it might apply to this study.

Other writers have eschewed Rice's model and held the more obvious but trivial view that the act of exchange

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[4]Herbert E. Klarman, *The Economics of Health* (New York, 1965), p. 15.

[5]Ibid., pp. 131-36.

[6]Rice, pp. 87-91.

[7]Ibid.

[8]Ibid.

defines the buyer-seller relationship between patients and hospitals. In a 1970 article, M. Brown, Jr., while recognizing that the patient's decisions regarding hospital care were in fact his physician's decisions, took issue with the view that the physician was the hospital's customer: "[T]he economic fact that the consumer-patient pays for and consumes [hospital] services should be perfectly clear."[9] Brown then commented on arguments by Rice and others:

> Some writers have made the argument that the medical staff physicians are the real customers of the hospital. This is difficult to justify, unless one can make the argument that the hospital sells to the physician the service of making facilities available for him to treat his patients. And this might not be such a bad argument.[10]

Nevertheless, the notion that the physician is the hospital's customer (or at least the origin of demand for hospital care) is a view that finds substantial support in the literature. Therefore, it is a basic assumption for the analysis in this study.

## Hospital Cost Behavior: Its Measurement and Causes

At this point it might be well to raise the issue of using "costs" rather than "prices" in the empirical section of this study. The price data that are available on a

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[9]Max Brown, Jr., "An Economic Analysis of Hospital Operations," Hospital Administration, XV (Spring, 1970), p. 65.

[10]Ibid.

hospital-by-hospital basis are prices charged by hospitals for basic semiprivate accommodations and those prices charged for a few of the more popular ancillary items. Such prices are not very useful unless one also has available the particular use-rates of the ancillary items by the "usual" patient. These data are not available on a hospital-by-hospital basis. Because of the general nonprofit organization of hospitals, it has been said that "costs" are really "prices" in this industry.[11] M. S. Feldstein felt that total expenditure data were superior to the price data because all patient care expenditures were included in cost series that were not so included in any price series for the hospital industry.[12] In defending his use of "costs" rather than "prices" in his study of inflation in the hospital industry, Feldstein said: "The 'average daily service charge' which is used as the hospital component of the consumer price index is both conceptually inferior [to available cost series] and not available for individual states [or individual hospitals]."[13]

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[11]Joseph D. Newhouse, "Toward a Theory of Nonprofit Institutions: An Economic Model of a Hospital," American Economic Review, LX (May, 1970), p. 67.

[12]Martin S. Feldstein, "Hospital Cost Inflation: A Study of Nonprofit Price Dynamics," American Economic Review, LXI (December, 1971), p. 859. See especially note 22, ibid.

[13]Ibid.

K. Davis took issue with the notion that "costs" are equivalent to "prices" in the hospital industry.[14] The results of her study indicated that in time periods before 1969, there was little basis for the conclusion that prices were equivalent to or were some simple transformation of costs. However, for the year 1969, the last year included in Davis' study, her results furnish substantial support for the equivalency of costs and prices in the hospital industry.[15] Given some degree of equivalency between costs and prices in this industry, the consumer price index series can be a valuable measure of hospital cost behavior. Additionally, annual issues of the American Hospital Association Guide to the Health Care Field detail enough total cost and other relevant data to allow abstraction of an adequate average cost series. Another measure of hospital price (cost) behavior is found in what has become an annual feature in the Social Security Bulletin. Under the title of "National Health Expenditures, 1929-71," D. P. Rice and B. S. Cooper have discussed the equivalency of costs and prices in the hospital industry. They noted that the rates of growth of these measures have been both quite high and

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[14]Karen Davis, "Relationship of Hospital Prices to Costs," Applied Economics, IV (1971), pp. 115-25.

[15]Ibid. Davis tested the constancy of the ratio of semiprivate room charges (prices) to average total costs. Only in 1969 did she find that the coefficients of other independent variables included in her model were not different from zero. Additionally, the values of $R^2$ were smaller in later years in all models indicating random rather than predictable variations in the ratios of prices to costs in later years (1965 and 1969). Pp. 118-23.

quite similar.[16] Rice and Cooper's measures do not, however, show area-by-area or state-by-state differences in either cost or price changes.

The causes of cost and price increases in the hospital industry that are cited in the literature are held to be any or all of those events and factors that tend to cause higher costs and prices in any industry. Some writers cite increased demand for hospital care resulting from higher incomes or a shift in preferences toward professional health care, or resulting from an effective reduction in the price of hospital care perceived by insured patients. Others make reference to increased labor costs and a general increase in the prices of hospital inputs. There is a whole new literature emerging regarding the adverse effects of the lack of the profit incentive. There is also a general recognition that the satisfaction of physician wants puts upward pressure on costs and prices in this industry. Rapid development and implementation of new medical technologies is given as another cause of cost and price increases in the hospital sector. A fairly complete discussion of the causes of hospital cost increases is included in M. S. Feldstein's article.[17] Further citation and discussion here would appear to be a rather sterile exercise. It is interesting

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[16]Dorothy P. Rice and Barbara S. Cooper, "National Health Expenditures, 1929-71," Social Security Bulletin, XXXV (January, 1972), p. 4.

[17]M. S. Feldstein, pp. 853-54.

to note, however, that the presence or absence of competition in the hospital industry is seldom even mentioned in the literature, let alone cited as a cause of cost or price increases.

## The Structure of Markets for Hospital Care and the Market Performance of Hospitals

It was stated above that there is little mention of the structure of markets in the literature pertaining to the hospital industry. It appears that the institutional non-profit organization and the benevolent goals of this industry have discouraged investigators who might otherwise have been interested in the effects of monopolized and competitive hospital care markets.[18]

The purpose of this study as implied earlier is to examine and to test the role that market structures play in the hospital cost inflationary mechanism. It is apparent that an analysis of the production processes in the medical care industry showing that hospitals are producers of intermediate rather than final medical goods and services does little to explain hospital cost behavior. However, an understanding of the response of hospitals to meet the wants of their physician-customers within the peculiar institutional

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[18] Such a statement is, of course, a judgment by this writer and is based on both his evaluation of the literature included here and on his evaluation of other works.

setting of the medical care industry will lead to economically predictable responses in hospital costs and an understanding of the inflationary mechanism that might not be forthcoming if a more usual view of the production processes and market relationships is held.

The hypothesis to be tested in this study states that more intense competition in the hospital industry results in higher average costs. In this sense, the "degree or intensity of competition" is a measure of the structure of markets for hospital care. The term "degree or intensity of competition" needs explicit definition in the way it will be used in the study. Hospitals "compete" for the revenue-producing powers of the physician population. If there is a single hospital in a market area, the hospital is a monopolist and the physician population must acquire the hospital care desired to produce therapies for patient-customers from a single seller of this medical input. If, however, there are several hospitals in a market area (a higher degree of competition), the physician population may choose among several sellers and select the ones that best suits its wants. Hospitals compete not by lowering their prices but by offering physicians the mix of hospital goods and services that best complement physicians' own resources in the production of medical care for their patients.

In his study, E. M. Kaitz did not directly approach the question of the market structure where hospital care is sold; he did explore the differential response of isolated or rural (monopoly) hospitals versus urban or suburban (competitive) hospitals.[19] The portions of Kaitz's findings that apply to this study were that hospital administrators usually responded in a positive fashion to the individual physician's wants regarding facilities, equipment, and even regarding brand name drugs and disposable supplies. Kaitz reported that hospital administrators faced more intense pressure from physicians for expanded facilities and services in urban and suburban markets than in isolated rural markets. Administrators said they were able to resist the "unreasonable" demands of medical staff more readily if physicians were not able to "shop" among several hospitals to find ones that would best satisfy their wants (in exchange, of course, for their ability to provide hospitals with revenue-producing patients).[20] In other words, competition made hospitals more willing to try to satisfy the wants of their customers (physicians). This is exactly what economic theory predicts. But without accounting for the institutions and customs regarding the production processes and the payments mechanism in the medical care industry, the predictions regarding cost behavior in the hospital care industry might be in error or might appear to be in conflict with a principle of economics.

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[19] Kaitz, pp. 79-80.

[20] Ibid., pp. 149-56.

M. L. Lee borrowed Veblen's terminology in describing the response of hospitals to physicians. He recognized that physicians were demanders of hospital care and described the response of hospitals to satisfy the wants of physicians as "conspicuous production."[21] Lee discussed the effects of competition among hospitals on their costs:

> [C]ompetition among hospitals for physicians results in expanding and improving the inventory of inputs to meet the demands of physicians, and, part of the expenses incurred in connection with the expansion and improvement of the inventory of inputs may be regarded as implicit payments to the physicians--a price paid to attract physicians.[22]

Unfortunately, Lee did not subject this observation to an empirical test. He hypothesized that hospitals were maximizing "status" and that high status hospitals attracted physicians who would provide revenue-producing patients.[23] However, the behavior described by Lee is quite congruent with either profit maximization or output maximization within a break-even constraint if hospitals recognize the physician as their customer and respond to him appropriately in order to attract him and his revenue-producing patients. Lee's discussion of empirical possibilities applies directly to the thesis of this study. Lee was not able to test explicitly his hypothesis that there was more "conspicuous

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[21]Mah Lin Lee, <u>A Conspicuous Production Theory of Hospital Behavior</u>, Studies in Health Care, Report No. 6 (Columbia, Mo., 1970), p. 2.

[22]Ibid., p. 4.

[23]Ibid.

production" where hospitals had to compete for a physician population. He did, nevertheless, calculate a statistically significant correlation coefficient (.16) between average costs of hospitals and the number of hospitals per thousand square miles.[24] Lee termed this measure of concentration a measure of "the degree of oligopolistic interdependence."[25] In terms used in this study, such a measure of concentration might be a crude measure of competitive or noncompetitive markets, i.e., the structure of the markets in which hospital care is sold. Lee's results, however tentative, lend some support to the central hypothesis of this study.

Where it is assumed that physicians are viewed as customers by hospitals, it would be helpful to analyze the theoretical considerations of such a relationship. Initially, the analysis below assumes that patients do not own hospitalization insurance.

In a monopoly market, a hospital would consider the demand for its output, the costs of production, and attempt to maximize profits or attempt to maximize some other objective function if profits are deemed to be an inappropriate maximand. Revenues accrue to a hospital from charges paid by patients; costs accrue as a result of providing goods and services required by physicians in their private practices. Since hospital costs and the costs of many other intermediate

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[24]Ibid., p. 21.

[25]Ibid.

medical goods and services are not viewed by the physician as costs within the business organization of his personal practice, the physician may or may not select least-cost combinations of inputs in producing therapies for his patients, even if he does select least-cost combinations of the inputs he owns. If the physician selects hospital care in such a situation when a less expensive input would be the more economically efficient choice, the demand for hospital care will increase, thereby increasing hospital costs. And he may want specialized equipment and facilities to be supplied by the hospital to avoid making a personal investment that might result in personal losses rather than personal profits. Whether or not these facilities and equipment might be "profitable" for a hospital, they will almost certainly increase costs. If the physician prescribes hospital care in order to use these items and facilities, the demand for hospital care increases, again, increasing hospital costs. The monopoly hospital can, however, act as a restraint by making its decision regarding any investment response to physician wants based on an examination of the effects of its response on its "profits" (or on another objective function). In a more competitive market structure where more than one hospital competes for the patient-admitting powers of the physician population, those physicians who organize their practices to attract patients who are affluent and pay their medical care bills promptly will be the physician-customers for whom hospitals will compete most vigorously. If one of those physicians desires equipment or facilities that are not available in the community, competing hospitals may have great incentive to a acquire the wanted items to attract his revenue producing abilities. And even if the physician has the items available at a particular hospital, a competing hospital may acquire duplicate items in hopes of attracting him and his "profitable" patients. There is, therefore, the possibility of capital redundancy and higher costs among those hospitals in areas where the market structure is other than monopolistic.[26]

However, there exists a final restraining market force in the form of the patient-customer's demand function for the final good, medical care. If hospital costs and prices are too high, the patient might well purchase less costly treatment in a less competitive hospital market. Both physicians and hospitals must react by restraining costs to avoid such a possibility which would reduce their revenues. Even this final market restraint may not apply if the patient owns a hospitalization insurance policy.

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[26]Kaitz, p. 79. Also see Newhouse, "Toward a Theory of Nonprofit Institutions," pp. 66-74. Newhouse discussed the behavior of physicians towards hospitals and also the behavior of consumers who owned hospitalization insurance.

## The Role of Insurance in the Demand for Medical Care

When an individual owns a hospitalization insurance policy, he perceives the price of hospital care to be zero or to be reduced greatly depending on the provisions of his particular policy. Therefore, the physician and the hospital escape the discipline of the market response of the patient to high-priced hospital care. The existence of universal insurance coverage of hospital care will make hospitals producing in either a monopolistic or more competitive market structure feel freer to respond to their physician-customers' wants.

> If every patient had full coverage cost-based hospital insurance, there would be no constraint on the amount of capital and labor that physicians combine with their services. Capital and labor would therefore be employed up to the point at which the marginal contribution of each to the physician's revenue was zero. This produces "Cadillac-quality" medicine. The only constraint on the use of these inputs would be offered by the upper limit on the number of things a hospital can do for a patient which might have some justification. Over time, technological change might be expected to relax even this constraint.[27]

Of course, not all consumers own such "full coverage cost-based hospitalization insurance." But only a very small proportion of the population does not own some kind of hospitalization insurance. Some estimates report that only

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[27] Mark Pauly and Michael Redisch, "The Not For-Profit Hospital as a Physicians' Cooperative," American Economic Review, LXIII (March, 1973), p. 96.

3 or 4 percent of the persons aged 65 and over have no hospitalization coverage and only 12 percent of those persons under age 65 have no hospitalization insurance coverage.[28]

The Blue Cross Association and other insurance industry associations compile and publish annual series that outline the distribution and structure of private health insurance coverage. A more complete compilation of these data is an annual feature in the Social Security Bulletin.[29] This annual study includes some information regarding the insurance-type public health care programs such as Medicare. These data summarized in the Social Security Bulletin indicate that the distribution of some form of health insurance or insurance-type public programs has reached a surprisingly large proportion of the population, over 90 percent by some estimates. An almost universal feature of these insurance policies and of the public programs is some form of hospital care coverage.[30] Substantially smaller percentages of the population (less than 50 percent) owned policies or had benefits from public programs that covered such medical care goods and services as treatment in their physicians' offices or prescribed drugs that were not administered in hospitals.[31]

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[28] Marjorie S. Mueller, "Private Health Insurance in 1971: Health Care Services, Enrollment, and Finances," Social Security Bulletin, XXXVI (February, 1973), p. 3.

[29] Ibid., pp. 3-22.

[30] Ibid.

[31] Ibid., pp. 3-7.

The broad distribution of medical care insurance in the economy and the resulting increase in demand for medical goods and services is cited as contributing to increased costs in this industry. Similarly, the structure of medical care insurance coverages, i.e., hospital care being more intensely insured, contributes to increased costs in the hospital sector of the industry.

> When insurance covers part of each patient's hospital bill, the factor prices of hospital inputs are effectively reduced . . . [to physicians]. One would expect an increase in the usage of hospital inputs relative to physician inputs for producing a given output. Hospital unit costs would rise.[32]

Such an increase in demand (and costs) in the hospital sector might not be so apparent if hospital care was not such a good substitute for many other medical goods and services.

The diagram in Figure 1 is useful to illustrate this phenomenon. The diagram is a consumer's preference map relating "hospital care" and "all other goods and services" and can be used to illustrate the behavior of a consumer who owns a hospitalization insurance policy. Since other medical goods and services, such as treatment in the physician's office, are less intensively insured, they are included in "all other goods and services" on the vertical axis of Figure 1. It is assumed that the consumer in question has received his insurance policy without personal expenditure

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[32]Pauly and Redisch, p. 96.

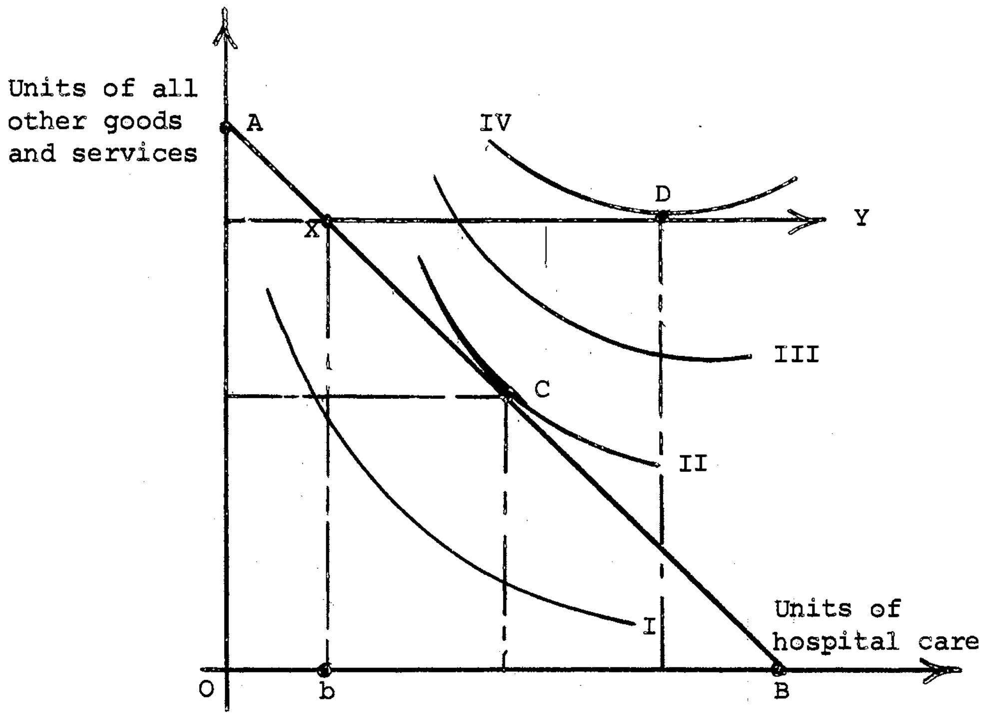


Figure 1. The Effects of Hospitalization Insurance

as a fringe benefit of employment, advanced age, or poverty. This is not an unrealistic starting point; over 100 million persons in addition to a large proportion (over 80 percent) of the 76 million Blue Cross members pay nothing or substantially less than actuarial cost for their hospitalization insurance through employer plans, Medicare, or Medicaid.[33] Also assume (for the sake of realism) that the consumer is subject to a small "deductible" on all insured stays in a hospital. This is represented by quantity O-b on the "hospital care" axis in Figure 1. Curves I-IV are

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[33]Mueller, pp. 4-5, and Margith Pachl, "The Use of Hospitals by Blue Cross Members in 1971," Blue Cross Reports, Research Series 10 (May, 1973), p. 3.

indifference curves relating the consumer's preferences between hospital care and all other goods and services. Line A-B is the consumer's income constraint. Point C represents the consumer's consumption pattern before he acquired the hospitalization insurance policy. Line A-X-Y represents the consumer's income constraint after he received the insurance policy as a "fringe benefit." He pays market price for the first "deductible" quantity of hospital care (O-b) and then perceives the price of all further hospital care to be zero.[34] Point D represents the consumption pattern of the consumer after receiving the hospitalization insurance policy. This particular behavior depends on hospital care being almost fully insured and other substitute medical goods and services being less fully insured; the patient substitutes quite adequate "free" goods and services (hospital care) for "costly" alternative medical goods and services. This phenomenon is described by the insurance industry as "moral hazard," i.e., the owner of the policy behaves in a "morally deficient" manner as compared to how he would behave without the insurance policy.

Moral hazard refers to the tendency of those persons with insurance benefits for particular purchases to consume more of the insured good or service than before those benefits were available. The insurance industry and some

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[34] Mark V. Pauly, "The Economics of Moral Hazard: Comment," American Economic Review, LVIII (June, 1968), p. 535.

economists consider such behavior to represent a "moral flaw" in human character.[35] But some writers consider such behavior to be the economically rational reaction of consumers who perceive the prices of insured purchases to be reduced or even free once the consumer is entitled to insurance-type benefits.[36] An interesting exchange regarding these opposing views occurred between K. J. Arrow and M. V. Pauly over the view taken by Arrow in his article, "Uncertainty and the Welfare Economics of Medical Care."[37] Pauly took issue with the notion that the acquisition of insurance benefits increasing the quantity demanded of the insured purchases represented some moral flaw in consumers. His analysis demonstrated

> . . . that the response of seeking more medical care with insurance than in its absence is a result not of moral perfidy, but of rational economic behavior. Since the cost of the individual's excess usage is spread over all other purchasers of that insurance, the individual is not prompted to restrain his usage of care.[38]

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[35]In the health insurance industry it is held that such a "moral flaw" extends to physicians and hospitals in that both must cooperate with the patient in his "scheme" to substitute insured hospital care for uninsured other medical goods and services.

[36]Pauly, "The Economics of Moral Hazard," p. 535.

[37]Kenneth J. Arrow, "Uncertainty and the Welfare Economics of Medical Care," American Economic Review, LIII (December, 1963), pp. 941-73.

[38]Pauly, "The Economics of Moral Hazard," p. 535.

Arrow's response to this particular passage of Pauly's was:

> We may agree certainly that the seeking of more medical care with insurance is a rational action on the part of the individuals if no further constraints are imposed. It does not follow that no constraints ought to be or indeed that in certain contexts individuals should not impose constraints on themselves. Mr. Pauly's wording suggests that "rational economic behavior" and "moral perfidy" are mutually exclusive categories. No doubt Judas Iscariot turned a tidy profit from one of his transactions, but the usual judgment of his behavior is not necessarily wrong.[39]

Notwithstanding judgments of "moral perfidy," the preceding exchange exemplifies a consensus in the literature regarding the effect of insurance on the demand for medical care.

A more subtle effect on the structure of insurance coverage itself that results from the demand for hospital care has also been reported. Pauly suggested that the tendency in the U. S. economy for consumers to acquire hospitalization insurance rather than full-coverage medical care insurance could be explained by assuming that consumers were "risk averters."[40] Hospital stays were more "random" (risky) events than other kinds of medical events and were, therefore, more likely to be insured by "risk averting" consumers. The larger proportion of consumers with hospitalization insurance as compared to full-coverage medical care insurance results in an increase in the demand for hospital care by insured consumers in the fashion discussed by Pauly

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[39]Kenneth J. Arrow, "The Economics of Moral Hazard: Further Comment," American Economic Review, LVIII (June, 1968), p. 538.

[40]Pauly, "The Economics of Moral Hazard," p. 534.

in his analysis of the effects of insurance on the demand for medical care.

H. Joseph reported that in hospital stays where there was some degree of substitutability between hospital care and some other less expensive forms of medical care, insured patients tended to choose longer term hospital care as opposed to outpatient treatment or treatment in their physicians' offices.[41] Joseph was investigating the impact of the moral hazard phenomenon on "length of stay." Klarman also spoke directly to the issue of substitutability:

> Whenever an insured service (say inpatient care) and an uninsured service (say ambulatory care) compete as potential substitutes for one another, the insured service is likely to be preferred by the patient and condoned by the physician.[42]

One of the conclusions that flows from these findings is that the pursuit of risk aversion affects the structure of health care insurance in that hospitalization insurance will be preferred by risk averting consumers. This will have an impact in the form of an increased demand for hospital services given the distribution of health care insurance and the institutions and traditions of the medical care industry itself. Even within a more realistic set of assumptions, the conclusions derived from the above analysis would still apply in some degree to the behavior of a consumer possessing a hospitalization insurance policy. Such

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[41]Hyman Joseph, "Hospital Insurance and Moral Hazard," Journal of Human Resources, VII (Spring, 1972), p. 160.

[42]Klarman, p. 32.

rational behavior on the part of consumers, most of whom own hospitalization insurance, is a basic behavioral assumption for the purposes of this study.

## Profit and Property Right Incentives

The presence or absence of the "profit motive" or of "property rights" in the hospital industry is presently an area of intense research interest in the economics profession. Many writers have concluded that the predominantly nonprofit organization of the industry has significantly contributed to cost increases. "It is believed that hospitals are not effectively restrained by market forces because of the absence of the profit motive and competition."[43] C. W. Baird held that profit incentives should be directly toward physicians because

> . . . the physician is not directly affected when his misuse of hospital facilities causes financial trouble for the institution, hence he has no incentive to minimize the cost of serving his patients. Physicians, of necessity, are the chief determiners of the uses of the hospital. They are the directors of the production of health.[44]

Baird also held that hospital efficiency would be better served if hospitals were owned outright by profit-maximizing physicians who might then benefit from innovations arising

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[43]Taylor, p. 46. The market performance of hospitals under varying degrees of competition is the subject of the hypothesis to be tested in this study. That hypothesis is in conflict with the effects of competition implied by Taylor.

[44]Charles W. Baird, "On Profits and Hospitals," Journal of Economic Issues, V (March, 1971), p. 58.

from the resulting competition among such profit-seeking organizations as would consumers of hospital care.[45]

M. Pauly and M. Redisch have analyzed the nonprofit hospital as a "physicians' cooperative."[46] They relied on both empirical evidence and the institutions surrounding the medical care and hospital industries to form a basis for their theorizing. They concluded that the observed behavior of nonprofit hospitals is most congruent with the objective function of "maximizing physicians' incomes."[47] Hospitals furnish physicians those medical inputs that best complement physicians' own resources. Pauly and Redisch recognized the demand-originating role of the physician in both for-profit and nonprofit hospitals but conclude that physicians are able to claim a larger share of the "residual income" (profits) from the production of medical care if those who control the hospital inputs used in production do not have any such claim on residual income in their objective functions.[48] To put it more simply, physicians' incomes are higher if the hospitals in which they practice are nonprofit organizations. Even if physicians owned the hospitals in which they practiced medicine, they might well earn more by

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[45]Ibid., p. 59.

[46]Pauly and Redisch, "The Not For-Profit Hospital," pp. 87-99.

[47]Ibid., p. 88.

[48]Ibid., p. 97.

practicing in truly nonprofit hospitals because of the risks associated with ownership. Pauly and Redisch suggest that this may explain the predominantly nonprofit development of the hospital industry in this country.[49]

Empirical investigations of the hospital industry are building a body of evidence that offers support to the theoretical conclusions regarding the beneficial effects of the presence of the profit incentive. In comparing production functions of for-profit and nonprofit hospitals, J. D. Ogur concluded that "the type of ownership has a significant effect on the level of quantity of output obtained from a given level of input use."[50] Ogur further held that

> . . . if the for-profit . . . type of hospital ownership were substituted for the nonprofit type, the results could well be . . . a reduction in resources devoted to . . . the purchase of sophisticated, but little used equipment . . . an increase in overall efficiency in the industry . . . and an increase in the total quantity of service provided.[51]

The differences between these two kinds of hospital business organizations may be best exhibited by differences in services mix rather than by differences in efficiency. Cost differences may be partly the result of for-profit hospitals' preferences for particular kinds of physicians and

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[49] Ibid., p. 98.

[50] Jonathan D. Ogur, "The Nonprofit Form: A Test of the Theory for the Hospital Industry" (paper presented at the 42nd meeting of the Southern Economic Association, Washington, D. C., November 10, 1972), p. 9.

[51] Ibid., pp. 9-10.

the kinds of patients that those physicians serve rather than just a basic difference in efficiency. The behavior of for-profit hospitals to cater to particular kinds of physicians and patients while excluding others has been described as "cream skimming."

> Basically, there are two types of cream skimming. First, is the practice of excluding patients (1) with long-term or complex illnesses that may have low utilization of profitable testing services or require extensive facilities for treatment; or (2) who do not pay full charges, such as welfare, Medicaid, and Medicare patients. This can be accomplished by locating the hospital in a wealthy neighborhood, selecting for staff appointments only doctors with appropriate clientele, installing sophisticated emergency departments to attract cases which require high utilization of numerous facilities and other methods. . . . The second type of cream skimming is the offering of "profitable" services while not offering services which entail high investment and unit cost but are utilized at a low level. . . . The central question is whether or not a community needs the facilities. If they do and nonprofit hospitals are providing them while proprietary hospitals are not, proprietary hospitals are not meeting social obligations. However, if there is no real need for additional facilities, proprietary hospitals can be credited for realizing that further duplication leads to lower utilization and would only add additional unwarranted costs to the community's health care system. Until community need for particular facilities can be concretely documented, this issue will remain moot.[52]

Evidence cited at times to support the hypothesis that for-profit hospitals are cream skimmers relates to reports

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[52]David A. Stewart, "The History and Status of Proprietary Hospitals," Blue Cross Reports, Research Series 9 (March, 1973), pp. 6-7. It is unclear what is meant when Stewart refers to the "social obligations" of proprietary hospitals and "community need" for facilities. The fulfillment of social obligations and the satisfaction of community need would appear to be market processes. It is apparent that Stewart is viewing them in some other sense.

that patients do not stay as long in for-profit as they do in nonprofit hospitals.[53] It is said this indicates a more profitable patient population in that more profitable ancillary services are used more intensely during the first few days of a hospital stay. Also cited are the less extensive services available in for-profit hospitals. This restriction of services is said to "select" patients with the kinds of "profitable" ailments that the for-profit hospitals desire.[54] And an alternative hypothesis says that cost differences represent quality differences because for-profit hospitals produce "cheaper" (substandard) medical products. But it should be noted that quality differences between hospitals might well reflect the response to consumer (physician) preferences for different products rather than any effort to lower costs (increase profits) by producing substandard products.

Much evidence, however, indicates that the attachment of property rights to decision-making outcomes or the presence of the profit incentive results in more efficient, lower-cost production.[55] But only a proportion of the observed cost differentials between for-profit and nonprofit

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[53]Klarman, p. 110. Length-of-stay behavior contrary to that mentioned by Klarman was reported by D. B. Hill and D. A. Stewart in their "Proprietary Hospitals Versus Nonprofit Hospitals: A Matched Sample Analysis in California," Blue Cross Reports, Research Series 9 (March, 1973), pp. 11-12.

[54]Karen Davis, "Economic Theories of Behavior in Nonprofit Hospitals," Economic and Business Bulletin, XXIV (Winter, 1972), pp. 10-12.

[55]Baird, pp. 59-60.

hospitals should be ascribed to just profit motivated efficiency.

## Differential Behavior of For-Profit Versus Nonprofit Hospitals

The focus of this study is not on the relative efficiencies of these two kinds of hospital business organizations; rather the focus is on the market performance of all hospitals regardless of their particular profit-nonprofit organization. The question that must be raised for the purposes of this study is: Will for-profit hospitals respond to the wants of physicians in a manner similar to the response of nonprofit hospitals? The conclusion that might be derived from the discussion above indicates a cautious affirmative answer to this question. There exist no direct tests of this conclusion. However, K. W. Clarkson, in his investigation of property rights incentives on managerial efficiency, produced some data that lend tentative support to this conclusion.[56] He reported that nonprofit hospitals had a more formal and a more elaborate system of management and organizational structures than did for-profit hospitals. This required more time and effort (cost) on the part of private practice staff physicians.[57] Nonprofit hospitals

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[56]Kenneth W. Clarkson, "Some Implications of Property Rights in Hospital Management," <u>Journal of Law and Economics</u>, XV (October, 1972), pp. 363-84.

[57]Ibid., pp. 370-74.

were less interested in the opinions of staff physicians (their customers) and placed more restrictions on staff physicians for surgery privileges (earning power of a surgeon) than did for-profit hospitals.[58] And the nonprofit hospitals devoted less managerial effort to the supervision of patient care (the source of physicians' income) than did for-profit hospitals.[59] Clarkson's findings suggest that for-profit hospitals respond to or cater to the wants and interest of their physician-customers more intensely than do nonprofit institutions in at least some areas of their activities.

For the purposes of this study, similar response behavior between these two kinds of institutions is assumed. The empirical portion of this study includes a "Profit Motive" variable in the cost prediction equations. This serves as a test of this assumption. Unfortunately, there are only eight for-profit hospitals that report enough information to be included in the 107 Oklahoma hospitals in the set of observations for the empirical section of this study.[60] Any conclusions that might be forthcoming are thus rendered tentative, at best.

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[58] Ibid., pp. 374-76.

[59] Ibid., pp. 372-74.

[60] The American Hospital Association 1972 Guide to the Health Care Field (Chicago, 1972), pp. 176-81. Hereafter cited as AHA Guide.

## Summary

This chapter has reviewed those writings that directly pertain to the hypothesis of this study. Additionally, this chapter has developed and presented the theoretical foundations and the basic set of assumptions that are vital for a meaningful test of the central hypothesis of the study. There are included reviews of materials and the development of the theory regarding the production of medical care and its components, the measurement and causes of hospital cost increases with particular attention paid to the effect that the structure of markets might have on hospital costs, the effect of health care insurance on the demand for hospital care, and the effect of the profit incentive on the efficiency of hospital care production.

# CHAPTER III

# THE ANALYTICAL MODEL: DATA, THEORY, AND SYNTHESIS

## Introduction

This chapter examines the sources of the data, formulates the model for the analysis of the data and testing of the hypothesis, and derives variables from the data for inclusion in the model. There is a brief discussion of hospitals included in the set of observations. Appropriate economic and statistical theories are brought to bear regarding the formulation of the analytical model and the inclusion or exclusion of particular measures and variables from the model.

## Sources of the Data

Most of the data which are employed in the study are from the "Listing of Hospitals: Oklahoma" section of the *AHA Guide*.[1] In addition to providing data relating to many areas of the health care field, the *AHA Guide* lists considerable information on a hospital-by-hospital basis.

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[1]Data for Oklahoma hospitals are found on pages 176-81. An explanation of those data is given ibid., pp. 8-10.

Those data listed in the AHA Guide that are of particular interest for the purposes of this study include the following for each hospital in Oklahoma:

1. location by county and city or town,
2. capacity (number of adult and pediatric beds and the number of newborn bassinets),
3. type of service (short term, long term, special, etc.),
4. control (local, state, federal, or private; nonprofit or for-profit, etc.),
5. average patient population,
6. annual admissions and births,
7. occupancy rate,
8. annual expenditures (total and for personnel),
9. average full-time equivalent employees,
10. educational and teaching activities,
11. accreditations and other approvals, and
12. facilities and services available.

Most of the above data are available for each hospital in the state of Oklahoma. Only a few hospitals in the state do not report such information for inclusion in the AHA Guide; even these are listed by location, capacity, and control. Only one set of data necessary for testing the hypothesis of this study is not possible to derive directly from the AHA Guide; there is no way to determine if a particular hospital produces in a monopoly or in a more competitive market structure.

The determination of the relevant market in the hospital industry is most commonly made with reference to the patient population. However, given that physicians are customers of hospitals, the determination is more properly made with reference to the physician population. For the purposes of this study, the relevant market for a hospital is that area that included those physicians who were within "reasonable" commuting distance of the hospital. R. E. Berry likened markets for hospital services to markets for service stations, i.e., they are defined by reasonable commuting distances.[2]

Such a delimitation of hospital markets is far from ideal in that the term "reasonable" is, and will remain, a bit ambiguous. "Reasonable" commuting distances are, in fact, quite important considerations in the delimitation of hospital markets given that physicians are hospitals' customers. Physicians must confine the market area from which they acquire hospital services to a rather compact geographic region that allows short commuting times. Otherwise, much productive income-producing time would be wasted commuting to and from distant hospitals. Such a constraint would not apply in so telling a fashion if patients were viewed as hospitals' customers because of patients' relatively infrequent medical episodes that would require hospitalization.

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[2]Ralph E. Berry, Jr., "Competition and Efficiency in the Hospital Industry: The Structure of the American Hospital Industry" (unpublished Ph.D. dissertation, Harvard University, 1965), p. 23.

A rather simple procedure was followed in this study to determine if a particular hospital was a monopolist or produced in a more competitive environment. If there existed a single hospital in an isolated town or city, it was assumed that the hospital was a monopolist. And if there were two or more hospitals in a town or city, it was assumed that the hospitals were competitors. A more subjective approach was necessary to evaluate larger metropolitan areas. All hospitals within such an area were assumed to be in a competitive environment. However, a hospital in, say, the northern area of a large city would not be a competitor of a hospital in, say, the southern fringes of that city. Similar considerations were applied to those hospitals located in independent towns and cities contiguous to large metropolitan areas.

Additionally, there exist eight osteopathic hospitals in the state of Oklahoma, three of which report sufficient data to be included in the analysis. The institutions of the medical care industry are such that only those physicians that hold the Doctor of Osteopathic Medicine degree (D.O.) can practice in these hospitals. And holders of the D.O. degree do not customarily practice in other hospitals. Such constraints are beginning to be relaxed in many areas of the country but are still apparent in Oklahoma. Therefore, no osteopathic hospital, regardless of its location, was found to be in a competitive environment; there were no two osteopathic hospitals in the same community or within "reasonable" commuting distances.

## Formulation of the Analytical Model

The hypothesis to be tested is: "More intense competition in the hospital industry results in higher rather than lower average costs." A first task in undertaking such a test is to formulate and derive a cost function for hospitals. Data from different hospitals are then analyzed in such a relationship to evaluate the importance of differences in outputs in "explaining" variations in average costs among hospitals. Recognizing that the "output" of hospitals is in no sense a homogeneous good or service, it will be necessary to adjust for the nonhomogeneous or multiproduct nature of hospital output. Not only do hospitals produce multiple medical products, some also produce education for student physicians, nurses, and technicians. Since empirical data are not subject to <u>ceteris paribus</u> constraints, it is necessary to consider differences among hospitals in (1) the efficiency of production, (2) quality of output, (3) scales of plant, (4) factors of production, (5) factor prices, and (6) the subject this study's hypothesis, the degree or intensity of competition.

Such a cost relationship for a particular hospital can be stated as follows:

$$C/Q = f(Q, M, E, D, S, K, L, P, X) \qquad (1)$$

where

C = total cost of production

Q = a measure of hospital output

M = measures of the multiproduct nature of hospital output

E = measures of the efficiency of hospital production

D = measures of differences in the quality of output

S = a measure of the scale of plant or the capacity of a hospital

K = capital - a proxy for fixed factors of production

L = labor - a proxy for variable factors of production

P = prices of the factors of production

X = the degree or intensity of competition.

It will be useful to review each of the components of this relationship and determine how and if each are derived from the available data.[3]

The _AHA Guide_ reports annual total expenditures for each hospital. This is a rather ideal measure of the total cost of production (C) for each hospital. There are three measures of hospital output (Q) reported in the _AHA Guide_:

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[3]A complete list and identification of the above determinants of average cost, the data and variables that represent them, and the abbreviations that are used in the study are furnished in the Appendix to this study.

(1) annual admissions, (2) average patient population, and (3) annual births. Births really represent the output of a particular facility rather than total hospital output. The other two measures allow alternative formulations of the dependent variable in Equation (1). Average cost (C/Q) is formulated as "cost per admission" and as "cost per day of patient care" by converting "average patient population" into "annual patient days." These are different measures of average cost in that cost per admission depends on the number of patient days of hospital care. This could vary among hospitals depending on the ailments of the patients physicians admitted to hospitals and on the desires of both patients and physicians for long or short stays in a hospital. Both measures of average cost are subjected to separate analyses. "Cost per admission" is formulated from the data as:

$$(C/Q)_1 = CPAD = (\text{Annual total expenditures}) \div (\text{Annual admissions}) = (TCOST) \div (ADM)$$

and "cost per day of patient care" is:

$$(C/Q)_2 = CPPD = (\text{Annual total expenditures}) \div (\text{Average patient population} \times (365) = (TCOST) \div (CENSUS) \times (365),$$

the denominator of $(C/Q)_2$ being "annual patient days." The measure of output used with "cost per admission" (CPAD) is "annual admissions." In the analytical model, this is restated as "admissions per day" (ADMD) to avoid large cumbersome numbers present in the original data. The output measure used with "cost per day of patient care" (CPPD) is "average patient population" (CENSUS) taken directly from the AHA Guide. Each of these measures is entered in the respective cost functions in both linear and quadratic forms in order to test the assumption of the "U" shapedness of the average cost curves.

The derivation of a measure of the "multiproduct nature of hospital output" (M) presents some theoretical problems. The AHA Guide reports whether or not each hospital has particular facilities or offers particular services and whether or not there exist particular educational programs in hospitals. These data are explicit indications of the multiproduct nature of hospital output. However, redundancy of facilities and services among hospitals is implicitly hypothesized in this study as being the result of competition among hospitals for physicians. Each facility or service can be adjusted for such a dependency on competition by adding "interaction" variables in the form of "degree of competition" times each facility or service. Such a statistical process would be very "expensive" in terms of degrees of freedom. Given the relatively small number of hospitals (observations) in the state of Oklahoma, such an adjustment is not attempted in the analysis. It is not known what impact the absence of this adjustment might have on the analytical results.

Other investigators have attempted to adjust for the multiproduct nature of hospital output in less subtle fashions. W. J. Carr and P. J. Feldstein adjusted hospital output for this multiproduct characteristic by including the number of such facilities and services in each hospital as a separate independent variable in their cost equations.[4] The problem with such an approach is that there is an implicit assumption that the strength and direction of the impact on cost of each facility or service is identical.[5] Nevertheless, this adjustment proved valuable in Carr and Feldstein's analysis of hospital costs. R. E. Berry, in approaching a similar adjustment problem, included each service and facility as a separate independent variable in his regression equations.[6] This technique overcame the weakness of Carr and Feldstein's approach regarding the strength and direction of the effect on cost of particular facilities and services. Therefore, in this study, Berry's method is approximated and each facility, service, or educational program that exists in three or more hospitals appears as a separate independent variable in the model. The restriction on "three or more"

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[4]W. John Carr and Paul J. Feldstein, "The Relationship of Cost to Hospital Size," Inquiry, IV (June, 1967), pp. 54-57.

[5]Ralph E. Berry, Jr., "Product Heterogeneity and Hospital Cost Analysis," Inquiry, VII (March, 1970), p. 70.

[6]Ibid., pp. 71-73.

occurrences is an attempt to avoid the problem of tautological results arising from statistical procedures.

Measurement of the efficiency of hospital production is conceptually difficult given the multiproduct characteristic of this industry. Berry held that there were no data from which a measure of efficiency could be derived.[7] However, the AHA Guide contains data that are somewhat suggestive of efficiency measures. "Occupancy rate" (ORATE), the ratio of "average patient population" (CENSUS) to the "number of adult and pediatric beds" (BEDS) is a measure of output to capital as is "admissions per bed" (ADBED), the ratio of "annual admissions" (ADM) to the "number of adult and pediatric beds" (BEDS). A more subtle measure of the "efficiency of hospital production" might be "length of stay" (LSTAY), the ratio of "annual patient days of care" to "annual admissions" (ADM). And the number of births per newborn bassinet (BBASS) is a measure of output to capital in a particular hospital department. While no one (or even all) of these ratios is entirely adequate, each is suggestive of a measure of a particular kind of efficiency. Therefore, these ratios are included as separate independent variables in the analytical model.

The "measure of the quality of hospital output" ["D" in Equation (1)] encounters conceptual and data problems similar to those encountered in the case of efficiency. Berry

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[7]Ibid., p. 70.

again held that data regarding the quality of hospital output do not exist.[8] But, again, some data reported in the AHA Guide, as in the case of efficiency, are suggestive of "quality." Accreditation by either the American Hospital Association or by the American Osteopathic Hospital Association (ACCR) indicates that such hospitals have met standards that likely enhance the quality of their outputs. And affiliation of a hospital with a medical school (MEDSCH) says much the same regarding standards and quality of output. Similarly, approval of a hospital for reimbursement by Blue Cross plans (BCROSS) or by Medicare (MEDCRE) also indicates that particular standards have been met. However, meeting particular standards speaks only to the potential for enhanced output quality, not to its certainty. Even considering the conceptual weakness of these measures, ACCR, MEDSCH, BCROSS, and MEDCRE are included separately in the model as measures of the quality of hospital output.

It was suspected early in this study that there would exist a high degree of collinearity between particular data. For instance, it was logical to assume that measures such as "total expenditures" and "capacity" would be highly correlated. Additionally, it was suspected that measures such as "full-time equivalent personnel," "annual personnel expenditures," "annual admissions," "average patient population," and others would be highly correlated, not only with "total

[8] Ibid.

expenditures," but with "capacity" and each of the other measures mentioned. Such suspicions, if confirmed, would cause serious multicollinearity if more than one of these measures are used as independent variables in a multiple regression statistical model. First order correlation coefficients were calculated for each pair of data from the AHA Guide and many of the ratios of data and variables considered for inclusion in the analytical model. An abbreviated summarization of those results as they apply to this discussion is presented in Table I. It is shown that there exist very large correlations between each of the measures of output and any of the measures that might be used to represent "capacity," "capital," or "labor." Measures of output are deemed theoretically crucial to the cost relationship; and since the addition of any measures of "capacity," "capital," or "labor" to the analytical model introduces serious multicollinearity with already-included output measures, direct measures of capacity, capital, and labor are excluded from the model. This particular solution to the multicollinearity problem biases the statistical estimate of the effect of output on average cost. In this particular case, the effect of output on average cost is biased upward.[9] In a sense, "output" is serving as a substitute or proxy for the independent variables: output, capacity,

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[9]David S. Huang, Regression and Econometric Methods (New York, 1970), pp. 149-58.

TABLE I

MATRIX OF CORRELATION COEFFICIENTS: TEST FOR COLLINEAR DATA*

| | ADM | CENSUS | BIRTHS | BEDS | BASS | PERNL | PCOST | TCOST |
|---|---|---|---|---|---|---|---|---|
| ADM | 1.0000 | .9886 | .9262 | .9743 | .9046 | .9722 | .9697 | .9741 |
| CENSUS | | 1.0000 | .9069 | .9895 | .8907 | .9865 | .9821 | .9868 |
| BIRTHS | | | 1.0000 | .8900 | .9142 | .9185 | .9182 | .9140 |
| BEDS | | | | 1.0000 | .8833 | .9827 | .9826 | .9855 |
| BASS | | | | | 1.0000 | .8733 | .8800 | .8921 |
| PERNL | | | | | | 1.0000 | .9927 | .9902 |
| PCOST | | | | | | | 1.0000 | .9970 |
| TCOST | | | | | | | | 1.0000 |

ADM: Annual admissions
CENSUS: Average patient days of care
BIRTHS: Annual number of births
BEDS: Number of adult and pediatric beds
BASS: Number of newborn bassinets
PERNL: Number of full-time equivalent employees
PCOST: Annual personnel expenditures
TCOST: Annual total expenditures

*All tests of the hypothesis that rho = 0, the probability that the absolute value of rho > $|r|$, were equal to or smaller than .0001 for each cell in the matrix.

capital, and labor. However, no conclusions can be made regarding the magnitude of the bias and the magnitude of the effects of the excluded variables.

While the model includes no measures of the "scale of plant or capacity" (S) or no measures of "capital or fixed factors of production" (K) or "labor or variable factors of production" (L), it is possible to include the ratio of labor to capital (L/K) without encountering multicollinearity problems. "Full-time equivalent employees" (PERNL) is used as the numerator, and the sum of "number of beds" (BEDS) and "number of newborn bassinets" (BASS) as the denominator of this ratio of L to K. This is more accurately the ratio of labor to "size" where size (BEDS plus BASS) serves as a substitute for a measure of the quantity of capital. In the analytical model this ratio is named "PNLSIZ." This is not an adequate substitute for measures of either labor or capital but it does provide a gross indication of factor proportions.

The data are not sufficient to provide prices of the factors of production (P) called for in Equation (1). The <u>AHA Guide</u> separates only that proportion of total expenditures allocated for labor. Allocations of cost for capital and all other inputs to the hospital care production process are not collected or reported separately. Therefore, the only measure of the prices of factors that can be abstracted from the data is the wage rate. This is derived from the <u>AHA Guide</u> by dividing PCOST by PERNL, giving "average annual wage." This is a rather cumbersome number and was converted into "average daily wage" (DWAGE) for analytical use.

There was considerable discussion above regarding the potential effects of the presence or absence of the "profit incentive" on hospital costs. The AHA Guide indicates whether or not each individual hospital is organized as a profit-making institution. This indication appears in the model as an independent variable named "PM." It might be best classified as one of the measures of "efficiency." However, special interest in the effects of the "profit incentive" justifies this distinct category not indicated in Equation (1).

The derivation of the measure of the "degree or intensity of competition" was discussed above in some detail. This measure appears as a separate independent variable in the model as the number of other hospitals that are competing with the hospital in question. Its value is zero if the hospital is a monopolist, one if there are two hospitals in a market area, two if there are three hospitals, etc. This measure, indicated as "X" in Equation (1), is named "COMPT" in the empirical analysis. And as in the case of "PM," this measure might also best be categorized as one of the measures of "efficiency."

## Hospitals Included in the Set of Observations

Before specifying the analytical model, it is well to discuss the Oklahoma hospitals that make up the "set of observations" for this study. In order to impose as many ceteris paribus restrictions as possible for the analysis, particular hospitals are excluded from the set of observations. Those hospitals owned and operated by agencies of the federal government were excluded. They typically hire full-time staff physicians; their costs, therefore, are not comparable with those of similar hospitals that do not hire medical staff. Those hospitals that produce nontypical products were excluded. Examples are psychiatric, tuberculosis, and other specialized hospitals. Again, cost per unit of output was not comparable with cost in more usual general hospitals. And those hospitals that did not report sufficient data were excluded. Of the 155 Oklahoma hospitals listed in the AHA Guide, 107 met sufficient criteria to be included in the "set of observations." Those included are all "general medical and surgical" hospitals. Some are nonprofit institutions owned and operated by local governmental units and others are profit-making institutions owned and operated by individuals or corporations. The majority are nonprofit institutions owned and operated by private benevolent organizations such as churches and other religious groups.

## Specification of the Analytical Model

Equation (1) expresses a functional relationship between average cost of production in hospitals and those characteristics of hospitals and data from hospital care production that, according to economic theory, determine average cost. Particular measures of some of these characteristics and some "second best" substitutes for unavailable data have been discussed above in some detail. These were formulated into variables for inclusion in the analytical model. The model is specified in the form of a set of multiple linear regression equations. An equation for one particular hospital is:

$$C/Q_{1\,(or\ 2)} = b_o + b_1 Q_{1\,(or\ 2)} = b_2 [Q_{1\,(or\ 2)}]^2 + b_3 M_1 + \ldots + b_{36} M_{34} + b_{37} E_1 + \ldots + b_{40} E_4 + b_{41} D_1 + \ldots + b_{44} D_4 + b_{45} [L/K] + b_{46} P + b_{47} X + b_{48} [PM], \qquad (2)$$

where the $b_i$'s are the parameters of the model to be estimated and C, Q, M, etc., have been identified above.[10] It must be noted that there will be two distinct models in that alternative measures of output (Q) and average cost (C/Q) are employed in separate estimating equations as discussed above. These two models [Equation (2)] are subjected to the analytical methodologies which are discussed in the next chapter. A discussion of the expected algebraic signs

[10]Refer to the Appendix for complete identification of the components of Equation (2).

of the coefficients of each of the variables in Equation (2) is relegated to Chapter V so as to precede the discussion of the analytical results.

## Summary

This chapter has discussed the sources of data, the particular areas of economic theory and empirical investigation that concern the problems faced in this part of the study, and synthesized data and theory into an analytical model. The result is similar in form and specification to models utilized by other researchers to investigate variations in average cost among hospitals. Therefore, it is a useful starting point to evaluate the effect that the "degree or intensity of competition" has on average cost.

# CHAPTER IV

# THE METHODOLOGIES OF ANALYSIS

## Introduction

This chapter introduces and discusses the statistical tools and other analytical devices that are used to test the hypothesis and to interpret the results of that test. The major statistical and analytical technique used in this study is "multiple linear regression" as indicated by the specification of Equation (2). Variants of this technique such as "stepwise" regression and other "sequential model construction" methods are employed to develop the argument in support of the hypothesis. Modern computer programs are analytical methodologies in their own rights and those that are used in this study are discussed concurrently with the associated statistical techniques. Only a few particular tests of statistical significance are discussed in any detail as most are integral parts of the statistical and computer methods employed in the study. In addition to multiple regression techniques, the independent variables in Equation (2) are subjected to "factor analysis" to analyze the theoretical soundness of the grouping of variables to represent the "multiproduct nature," "efficiency," and "quality" of hospital output.

## Regression Analysis and Computer Methods

A collection of computer programs that is available for use through the Oklahoma State University Computer Center contains sufficient statistical tools and options to perform the bulk of the analytical processes in this study. This collection is the "Statistical Analysis System" (S. A. S.) developed by A. J. Barr and J. H. Goodnight.[1]

Both alternative forms of Equation (2) are fitted to the data using the S. A. S. multiple regression procedure. This procedure allows for an inspection of the multiple regression coefficients and their algebraic signs. Additionally, these results establish the proportion of the variation in average cost that can be explained by the model, i.e., the $R^2$ statistics for both forms of Equation (2). However, given the large number of independent variables (regressors) and the relatively small number of observations, meaningful interpretation of the results are tentative, at best. Aside from the "degress of freedom" problems, the number of regressors in the model presents a serious interpretation problem.

> Generally, when the number of independent variables becomes large, say, greater than 7, the interpretation of the regression equation becomes difficult. That is, we cannot pinpoint what is the cause of the . . . [variation in the dependent variable].[2]

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[1]Jolayne Service, *A User's Guide to the Statistical Analysis System* (Raleigh, N. C., 1972).

[2]Taro Yamane, *Statistics: An Introductory Analysis*, 3rd ed. (New York, 1973), p. 994.

While specifying a particular maximum number of regressors may be a bit arbitrary, there is no doubt that interpretation becomes clearer if the regression equation is constrained to some "reasonable" number of regressors.

It is assumed that of the 48 regressors in the model, some are not too "important" in explaining the behavior of average cost. Including those irrelevant regressors in a multiple regression model such as Equation (2) will "increase the variance of all the least squares estimates."[3] Eliminating them biases the least squares estimates unless the "true" values of their coefficients are zero.[4] In this study, the advantages that accrue by eliminating irrelevant regressors outweigh the problems introduced by such a process.

A popular technique to eliminate irrelevant regressors from a multiple regression model entails first regressing all independent variables and then inspecting the test statistics associated with each variable's coefficient and eliminating those whose test statistics are not sufficiently significant by some predetermined criterion. This belongs to that set of techniques known as "sequential model construction." A common danger associated with all such sequential methods is the tendency to allow them to replace

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[3]Potluri Rao, "Some Notes on Misspecification in Multiple Regressions," The American Statistician, XXV (December, 1971), p. 39.

[4]Ibid.

or to grossly intrude upon theorizing.[5] Such might be the danger in this study if the object of the analysis had been only to construct a "compact" cost-prediction equation. However, the object of the analysis is to assess the independent effects of the "degree of competition" on average cost by adjusting for other theoretically sound determinants of average cost. Therefore, techniques that select "important" regressors from a set already preselected on the basis of sound theorizing aids in achieving this object.

Programs in the S. A. S. collection contain several variations of "stepwise regression" that perform this selection process. There are options available in these programs that allow the investigator to specify various criteria for dropping, adding, or replacing regressors in the model. The "Forward Selection" stepwise regression routine from the S. A. S. collection first selects that regressor that produces the largest $R^2$ statistic from all regressors contained in the original model [Equation (2) in this case]. Then a second regressor is added, the criterion for its inclusion being that no other regressor would produce as large an "F" statistic had it been included instead. The routine keeps adding regressors until none can be found that produce an "F" statistic that is significant at some predetermined level.[6] The 50 percent (.50) level of significance is

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[5]T. D. Wallace and V. G. Ashar, "Sequential Methods in Model Construction," _Review of Economics and Statistics_, LIV (May, 1972), pp. 172-78.

[6]Service, "A User's Guide to the SAS," p. 127.

chosen for the purposes of this study. The stepwise regression routine that is named "Stepwise" in the S. A. S. collection performs the same selection functions as does the Forward Selection procedure. And as in Forward Selection, Stepwise stops adding regressors when no other regressor can be found that produces an "F" statistic that is significant at some predetermined level. But Stepwise then additionally checks to insure that all already-included regressors remain significant at some other predetermined level or be deleted from the model.[7] The level of significance chosen for "remaining in the model" is 10 percent (.10). The Stepwise procedure usually results in a model with fewer regressors than the Forward Selection procedure.

The "Maximum $R^2$ Improvement Technique" in the S. A. S. collection allows the investigator to choose a model that contains any number of regressors from one to as many as desired. The investigator has some assurance that whichever sized model is chosen, it will produce the largest $R^2$ statistic of any other model with the same number of independent variables. The Maximum $R^2$ procedure first selects the single regressor from those in the original equation that produces the largest $R^2$. Then a second regressor is selected that produces the largest gain in $R^2$. All excluded regressors are then compared with the first regressor to insure that no switch would produce a larger $R^2$. A third regressor is

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[7]Ibid., pp. 127-8.

selected and, again, all excluded regressors are compared but not with just the second but with all already-included independent variables. Any switches that would result in a gain in $R^2$ are made and then comparisons are again made before another regressor is added to the model. The procedure can be started and stopped with the numbers of variables that the investigator views as appropriate.[8]

This section of the chapter has outlined the principal analytical method that is used to test the study's hypothesis: multiple regression and some related sequential methods made possible by high-speed computers and appropriate "software." In addition to regressing all 48 variables in Equation (2), the techniques, Forward Selection, Stepwise, and Maximum $R^2$ Improvement, are employed to develop argument in support of the study's hypothesis. Particular results are discussed in detail but no model is selected as being the "best" single model.

## Test for Interaction

Given that the hypothesis is supported, it might be said that the "degree or intensity of competition" does not measure the independent effects of competition but, instead, measures some combination, say, of competition, output, size, and efficiency. Therefore, in addition to the independent variables in Equation (2), interaction variables are

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[8]Ibid., p. 128.

included in the form of "degree of competition" (COMPT) multiplied by each of the measures of efficiency and by the measure of output. Additionally, there are interaction terms included in the form of COMPT times the "labor to capital ratio" (PNLSIZ) and the "wage rate" (DWAGE). COMPT itself is included in quadratic form in order to discuss the possibility of some "optimum" intensity of competition. The variables to be added are:

(COMPT) × (COMPT) = COM_2

(COMPT) × (CENSUS) = CM_CS or
(COMPT) × (ADMD) = CM_AM

(COMPT) × (ORATE) = CM_OR

(COMPT) × (LSTAY) = CM_LS

(COMPT) × (ADBED) = CM_AB

(COMPT) × (BBASS) = CM_BS

(COMPT) × (PNLSIZ) = CM_PZ

(COMPT) × (DWAGE) = CM_DW

The addition of eight more variables to Equation (2) makes any attempt to interpret a regression including all variables almost hopeless. Therefore, only the stepwise regression procedures are employed to evaluate the extent of the interaction between COMPT and the other measures.

It was mentioned above that it would be desirable to analyze interactions between the degree of competition and measures of the multiproduct nature of hospital output. This is not attempted because of the large number of such measures in Equation (2). And if a cost prediction equation was the primary object of the study, it would be desirable to analyze interactions between all combinations of regressors. Given the particular object of this study, the analysis of interactions is restricted to the eight listed above in this section.

Evaluation of Sequential Methods

All of the stepwise regression procedures used in the study have a single purpose. They are used to eliminate those independent variables from Equation (2) and the added interaction variables that do little in explaining variations in average cost among hospitals. There is an implicit assumption that the multiple regression coefficients of the excluded regressors are equal to zero. A statistical test of this assumption is valuable in evaluating the sequential model construction methods that are used in the analysis. Huang discusses partial joint tests that use $R^2$ statistics for tests of hypotheses regarding the nullness or "zero values" of the coefficients of regressors excluded from a model.[9] An appropriate test of the hypothesis that the coefficients of "m" additional regressors are not different from zero is:

$$F = \frac{\Delta R^2/m}{(1-R^2) \;/\; (n-k-1)}$$

where "F" is evaluated with "m" and "n-k-1" degrees of

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[9]Huang, pp. 99-103.

freedom; $\Delta R^2$ is the gain in $R^2$ when the "m" variables are included in the model; "n" is the number of observations; "k" is the total number of independent variables $(m + x = k)$; and $R^2$ results from regressing all "k" regressors.[10] Even the importance of a single regressor can be evaluated with this test. An extension of this test allows the investigator to test the hypothesis that all of the independent variables in any sized model do not contribute to the explanation of the variation in the dependent variable.[11] If the calculated value of "F" is found to be statistically significant in any of the above tests, the null hypothesis regarding the importance of the excluded regressors is rejected. Conversely, a nonsignificant value of "F" says that the hypothesis that the excluded regressors are not important cannot be rejected. These "partial joint tests" are employed in the analysis to evaluate some of the results of the various stepwise regression procedures.

## Factor Analysis and the Determinants of Average Cost

The particular groupings of various data and measures to represent the determinants of average cost in Equation (1) are in agreement with economic theory. Empirical data,

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[10] Ibid., pp. 101-2.

[11] Ibid., p. 103.

however, do not always conform to theory. The technique of factor analysis applied to the independent variables in Equation (2) will produce a set of orthogonal "factors" consisting of correlations between each such factor and each independent variable. These correlations or factor loadings indicate the strength of the relationship between each independent variable and particular factors. Variables can be relegated to particular factors using these factor loadings as criteria. Berry employed this technique to discern particular product mixes produced by hospitals.[12] He was able to identify meaningfully eight factors that represented different characteristics of the multiproduct nature of hospital output.[13] Berry was encouraged by those results in that meaningful identification of factors is not always possible. This technique (again, from the S. A. S. collection) is applied to the regressors in Equation (2). The resulting factors are tentatively identified in order to gain some insights regarding the theoretical soundness for the groupings of variables in Equation (2) to represent output and its multiproduct nature, efficiency, quality, etc., that are identified in Equation (1).

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[12] Berry, "Product Heterogeneity and Hospital Cost Analysis," pp. 73-5.

[13] Ibid.

## Summary

This chapter has discussed the analytical methodologies that are employed in the test of the study's hypothesis and in other analytical processes. The statistical and computer methods that are employed in the analysis were discussed as were some particular tests to evaluate the results of those methods. A method to evaluate the particular formulation of the average cost relationship was also discussed.

## CHAPTER V

## EMPIRICAL RESULTS

### Introduction

This chapter discusses some a priori expectations and presents the results of the analysis of the model and the results of the testing of the study's central hypothesis. There is also a discussion of the results of a factor analysis of the model's independent variables in order to furnish some justification for the groupings of variables to represent the determinants of average cost.

The first section of the chapter discusses the a priori expectations of the algebraic signs of the multiple regression coefficients of the independent variables in Equation (2). The second section of the chapter presents the results of the regressions that include all of the independent variables in Equation (2). There is some emphasis in the discussion in this and other sections of the chapter on the second form of Equation (2) where the dependent variable is "cost per day of patient care" (CPPD). Such emphasis follows the lead of other investigators who have viewed the unit of hospital output as being a day of patient care more frequently than as being an admission (or discharge). The third section presents and discusses the results of the Forward Selection and Stepwise regression procedures. The implications of the results of "partial joint tests" regarding the reduction in the number of regressors are explored. The fourth section of the chapter presents and discusses the results of the Maximum $R^2$ Improvement Technique. As in the third section, the implications of tests are discussed. The fifth section of the chapter discusses the results of the tests for interactions between COMPT and other variables. The sixth section of the chapter presents the results of the factor analysis and discusses their implications regarding the formulation of the model.

## Some Theoretical Expectations

The direction and impact on average cost of only some of the independent variables in the model can be determined on the basis of economic theory. Table II lists each independent variable for both forms of Equation (2) and indicates for each the a priori expectation regarding the algebraic sign of its multiple regression coefficient. Where no determination can be made on the basis of theory or prior knowledge, a question mark appears. For instance, in the cases of RESI, INTERN, and NURSE, it is not known if the cost of such educational programs has a greater positive effect on average cost or if the lower-priced or free labor of students has a greater negative effect. Certain facilities and services are known to be quite expensive to acquire and operate.

TABLE II

EXPECTED SIGNS OF REGRESSION COEFFICIENTS

| Variable from Equation (2) | Abbreviation | Expected sign of coefficient when dependent variable equals: CPAD | CPPD |
|---|---|---|---|
| $Q_1$ | ADMD | − | ... |
| $Q_2$ | CENSUS | ... | − |
| $(Q_1)^2$ | AMD_2 | + | ... |
| $(Q_2)^2$ | CEN_2 | ... | + |
| $M_1$ | CANCER | ? | ? |
| $M_2$ | RESI | ? | ? |
| $M_3$ | INTERN | ? | ? |
| $M_4$ | NURSE | ? | ? |
| $M_5$ | RECOV | ? | ? |
| $M_6$ | ICU | + | + |
| $M_7$ | ICCU | + | + |
| $M_8$ | OHS | + | + |
| $M_9$ | FTP | ? | ? |
| $M_{10}$ | PTP | ? | ? |
| $M_{11}$ | XRT | + | + |
| $M_{12}$ | CBT | + | + |
| $M_{13}$ | RDT | + | + |
| $M_{14}$ | DRD | + | + |
| $M_{15}$ | TRD | + | + |
| $M_{16}$ | PATH | ? | ? |
| $M_{17}$ | BLBK | ? | ? |
| $M_{18}$ | ECEP | ? | ? |
| $M_{19}$ | IHTH | ? | ? |
| $M_{20}$ | PREM | + | + |
| $M_{21}$ | SCU | − | − |
| $M_{22}$ | EXCU | + | − |
| $M_{23}$ | RENI | + | + |

TABLE II (Continued)

| Variable from Equation (2) | Abbreviation | Expected sign of coefficient when dependent variable equals: CPAD | CPPD |
|---|---|---|---|
| $M_{24}$ | RENO | + | + |
| $M_{25}$ | PHTH | + | ? |
| $M_{26}$ | OCTH | + | ? |
| $M_{27}$ | REHO | + | + |
| $M_{28}$ | PSYI | + | + |
| $M_{29}$ | PSYE | + | + |
| $M_{30}$ | OPD | + | + |
| $M_{31}$ | EMR | + | + |
| $M_{32}$ | SWD | ? | ? |
| $M_{33}$ | HAX | - | - |
| $M_{34}$ | VLS | - | - |
| $E_1$ | ORATE | - | - |
| $E_2$ | ADBED | - | - |
| $E_3$ | BBASS | - | - |
| $E_4$ | LSTAY | + | - |
| $D_1$ | ACCR | + | + |
| $D_2$ | MEDSCH | + | + |
| $D_3$ | BCROSS | + | + |
| $D_4$ | MEDCRE | + | + |
| PM | PM | - | - |
| L/K | PNLSIZ | + | + |
| P | DWAGE | + | + |
| X | COMPT | + | + |

This knowledge alone, however, does not assure accurate prediction of the signs of multiple regression coefficients. Nevertheless, where there is even this degree of prior knowledge, the expected signs of the coefficients are indicated. Examples are the positive sign for the coefficient of CBT (cobalt therapy facility) and the negative sign for VLS (volunteer services department). Reference is made to this discussion and to Table II when the empirical results differ from these expectations.

## Multiple Regression Results: Forty-Eight Independent Variables

Both forms of the model were fitted to the data. Those results are summarized in Table III. In both cases, substantial proportions of the variation in average cost is explained by Equation (2). There are, however, some conflicts regarding the expected signs of the regression coefficients and the results of the regressions. In many instances, the test statistics are such that the importance of the conflicts can be discounted. In the cases of MEDSCH, BCROSS, MEDCRE, OHS, XRT, and EMR, the differences between expectations and results cannot be so easily discounted. While the test statistics for MEDSCH, BCROSS, and MEDCRE are not significant, the contrary signs and the magnitudes of the coefficients for three of the four measures of the quality of hospital output demand some comment. It may be that

TABLE III

REGRESSION RESULTS: ALL FORTY-EIGHT INDEPENDENT VARIABLES*

| Independent variables | | Dependent variable CPAD, $R^2$: .92466 | | | Dependent variable CPPD, $R^2$: .89387 | | |
|---|---|---|---|---|---|---|---|
| | | Coefficients (b values) | t-Scores $H_o$: b=0 | Prob. of a greater \|t\| | Coefficients (b values) | t-Scores $H_o$: b=0 | Prob. of a greater \|t\| |
| Intercept | | 190.572 | - | - | 79.800 | - | - |
| $Q_1$ | (ADMD) | - 2.554 | -0.747 | .536 | - | - | - |
| $Q_2$ | (CENSUS) | - | - | - | - 0.039 | -0.556 | .587 |
| $(Q_1)^2$ | (AMD_2) | 0.019 | 0.424 | .677 | - | - | - |
| $(Q_2)^2$ | (CEN_2) | - | - | - | 0.000+ | 0.430 | .673 |
| $M_1$ | (CANCER) | 43.217 | 0.526 | .607 | 10.796 | 0.910 | .630 |
| $M_2$ | (RESI) | 92.479 | 0.763 | .545 | 8.958 | 0.517 | .613 |
| $M_3$ | (INTERN) | 1.513 | 0.023 | .978 | - 0.782 | -0.090 | .926 |
| $M_4$ | (NURSE) | 58.949 | 1.163 | .248 | 2.918 | 0.406 | .689 |
| $M_5$ | (RECOV) | - 15.325 | -1.124 | .265 | - 2.418 | -1.246 | .216 |
| $M_6$ | (ICU) | 15.405 | 0.968 | .661 | 2.222 | 0.987 | .671 |
| $M_7$ | (ICCU) | [+] - 11.356 | -0.889 | .618 | [+] - 1.513 | -0.824 | .582 |
| $M_8$ | (OHS) | [+] - 39.361 | -0.942 | .648 | [+] - 7.848 | -1.306 | .194 |
| $M_9$ | (FTP) | - 0.211 | -0.012 | .987 | 0.371 | 0.149 | .877 |
| $M_{10}$ | (PTP) | 12.579 | 0.887 | .618 | 1.404 | 0.689 | .501 |
| $M_{11}$ | (XRT) | [+] - 57.186 | -2.220 | .029 | [+] - 9.861 | -2.658 | .010 |
| $M_{12}$ | (CBT) | [+] - 7.515 | -0.120 | .901 | 1.463 | 0.161 | .867 |

TABLE III (Continued)

| Independent variables | Dependent variable CPAD, $R^2$: .92466 Coefficients (b values) | t-Scores $H_o$: b=0 | Prob. of a greater \|t\| | Dependent variable CPPD, $R^2$: .89387 Coefficients (b values) | t-Scores $H_o$: b=0 | Prob. of a greater \|t\| |
|---|---|---|---|---|---|---|
| $M_{13}$ (RDT) | 14.841 | 0.322 | .747 | 2.535 | 0.383 | .705 |
| $M_{14}$ (DRD) | 56.491 | 2.594 | .012 | 7.623 | 2.401 | .019 |
| $M_{15}$ (TRD) | [+] -57.267 | -1.294 | .198 | [+] - 5.967 | -0.942 | .648 |
| $M_{16}$ (PATH) | 29.690 | 1.110 | .271 | 4.206 | 1.092 | .279 |
| $M_{17}$ (BLBK) | -15.769 | -1.279 | .203 | - 2.105 | -1.184 | .240 |
| $M_{18}$ (ECEP) | -11.382 | -0.317 | .751 | - 4.121 | -0.761 | .544 |
| $M_{19}$ (IHTH) | 12.140 | 0.698 | .505 | 2.072 | 0.837 | .589 |
| $M_{20}$ (PREM) | [+] -17.833 | -0.984 | .670 | [+] - 2.401 | -0.924 | .638 |
| $M_{21}$ (SCU) | [-] 0.021 | 0.001 | .999 | - 2.541 | -0.574 | .575 |
| $M_{22}$ (EXCU) | [+] -12.528 | -0.436 | .668 | - 0.504 | -0.121 | .900 |
| $M_{23}$ (RENI) | 15.613 | 0.271 | .734 | 4.238 | 0.507 | .620 |
| $M_{24}$ (RENO) | 23.023 | 0.365 | .717 | [+] - 0.804 | -0.087 | .929 |
| $M_{25}$ (PHTH) | [+] - 1.481 | -0.088 | .928 | - 0.280 | -0.116 | .904 |
| $M_{26}$ (OCTH) | 35.145 | 0.651 | .525 | 4.668 | 0.606 | .554 |
| $M_{27}$ (REHO) | [+] -21.625 | -0.355 | .725 | [+] - 4.679 | -0.521 | .611 |
| $M_{28}$ (PSYI) | 5.561 | 0.155 | .872 | 0.879 | 0.171 | .859 |
| $M_{29}$ (PSYE) | 19.326 | 0.505 | .621 | [+] - 0.061 | -0.011 | .988 |
| $M_{30}$ (OPD) | 43.195 | 2.050 | .042 | 5.802 | 1.909 | .058 |

TABLE III (Continued)

| Independent variables | | Dependent variable CPAD, $R^2$: .92466 Coefficients (b values) | t-Scores $H_o$: b=0 | Prob. of a greater \|t\| | Dependent variable CPPD, $R^2$: .89387 Coefficients (b values) | t-Scores $H_o$: b=0 | Prob. of a greater \|t\| |
|---|---|---|---|---|---|---|---|
| $M_{31}$ | (EMR) | [+] - 34.185 | -1.979 | .049 | [+] - 4.535 | -1.836 | .068 |
| $M_{32}$ | (SWD) | - 45.940 | -1.242 | .217 | - 6.585 | -1.263 | .209 |
| $M_{33}$ | (HAX) | [-] 12.521 | 0.920 | .363 | [-] 1.725 | 0.873 | .610 |
| $M_{34}$ | (VLS) | [-] 19.202 | .950 | .652 | [-] 2.076 | 0.726 | .523 |
| $E_1$ | (ORATE) | - 1.878 | -1.371 | .172 | - 0.374 | -1.896 | .060 |
| $E_2$ | (ADBED) | - 7.806 | -3.027 | .004 | - 1.001 | -2.755 | .008 |
| $E_3$ | (BBASS) | - 0.761 | -1.120 | .233 | - 0.132 | -1.429 | .155 |
| $E_4$ | (LSTAY) | 10.773 | 0.918 | .635 | - 5.833 | -3.447 | .001 |
| $D_1$ | (ACCR) | 7.737 | 0.479 | .639 | 0.756 | 0.324 | .746 |
| $D_2$ | (MEDSCH) | [+] - 34.845 | -0.264 | .789 | [+] - 4.850 | -0.258 | .793 |
| $D_3$ | (BCROSS) | [+] - 60.628 | -1.145 | .256 | [+] - 7.700 | -1.005 | .320 |
| $D_4$ | (MEDCRE) | [+] - 64.218 | -1.071 | .289 | [+] -10.461 | -1.220 | .225 |
| PM | (PM) | [-] 7.294 | 0.307 | .758 | [-] 1.114 | 0.325 | .745 |
| L/K | (PNLSIZ) | 260.300 | 8.850 | .000+ | 38.463 | 9.104 | .000+ |
| P | (DWAGE) | 26.197 | 6.904 | .000+ | 3.802 | 6.914 | .000+ |
| X | (COMPT) | 2.948 | 0.939 | .646 | 0.755 | 1.699 | .091 |

*Where the algebraic signs of regression coefficients are different from expected signs, the expected signs are indicated in brackets.

the additional controls and review of production by third parties such as medical school faculty, the Blue Cross Association, and Medicare personnel, enhances not only the quality of production in hospitals but also enhances the efficiency of production. The conflicting signs for the coefficients of OHS, XRT, and EMR may be explained by undetected interaction between these high-cost facilities and other hospital characteristics and facilities. It is not reasonable to assume, for instance, that open-heart surgery facilities (OHS) tend to reduce average cost as indicated by its negative coefficients.

The central hypothesis of this study, that more intense competition results in higher average cost, finds some support in these results. Such support is quite weak in the case of the average cost of an admission (CPAD) but rather strong in the case of the average cost of a day of patient care (CPPD). In the latter instance, the test statistic is not quite significant by usual criteria. However, this statistic and the sign of the coefficient of COMPT indicate that the intensity of competition has a positive impact on average cost.

Partial joint tests of the hypothesis that all 48 independent variables were not important in explaining the variation in average cost produced significant "F" ratios.[1]

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[1]When CPAD is the dependent variable, F = 14.83078 and when CPPD is the dependent variable, F = 10.17718.

This gives support to the assumption that some of the model's 48 regressors are important in explaining the behavior of CPAD and CPPD. But, of course, an inspection of the multiple regression coefficients and their test statistics also supports that assumption.

## Sequential Model Construction Results: "Forward Selection" and "Stepwise" Procedures

Both forms of the model were fitted to the data using the S. A. S. Forward Selection and Stepwise regression routines. These resulted in substantial reductions in the number of regressors in both forms of the model.

When CPAD was the regressand, the resulting models contained twenty regressors found by the Forward Selection procedure and eight by the Stepwise procedure. The results are summarized in Table IV. It is interesting to note the modest loss of the explanatory power of these "smaller" models in comparison with the "complete" model containing all 48 independent variables. There exist similar conflicts regarding these results and a priori expectations of the algebraic signs of some of the multiple regression coefficients as in the case when all independent variables were regressed. In the Forward Selection results, the signs of the coefficients of MEDSCH, MEDCRE, XRT, and EMR again conflict with expectations; in the Stepwise results, the signs of the coefficients of MEDCRE and EMR conflict with expected signs.

TABLE IV

REGRESSION RESULTS: FORWARD SELECTION AND STEPWISE REGRESSION PROCEDURES FOR DEPENDENT VARIABLE CPAD*

| Variables found by procedure | | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater \|t\| |
|---|---|---|---|---|
| Forward Selection Procedure, $R^2$: .91149 | | | | |
| Intercept | | 120.593 | - | - |
| $Q_1$ | (ADMD) | - 1.062 | - 1.178 | .240 |
| $M_2$ | (RESI) | 98.165 | 2.081 | .038 |
| $M_4$ | (NURSE) | 52.768 | 2.110 | .036 |
| $M_7$ | (ICCU) | [+] - 13.790 | - 1.564 | .118 |
| $M_{10}$ | (PTP) | 11.990 | 1.183 | .238 |
| $M_{11}$ | (XRT) | [+] - 44.735 | - 2.674 | .009 |
| $M_{14}$ | (DRD) | 34.301 | 2.337 | .021 |
| $M_{29}$ | (PSYE) | 37.888 | 1.976 | .048 |
| $M_{30}$ | (OPD) | 43.487 | 2.821 | .006 |
| $M_{31}$ | (EMR) | [+] - 25.313 | - 1.889 | .059 |
| $M_{34}$ | (HAX) | [-] 13.458 | 1.443 | .149 |
| $E_1$ | (ORATE) | - 1.400 | - 1.318 | .188 |
| $E_2$ | (ADBED) | - 7.909 | - 4.026 | .000+ |
| $E_3$ | (BBASS) | - 1.166 | - 2.864 | .005 |
| $E_4$ | (LSTAY) | 9.071 | .951 | .654 |
| $D_2$ | (MEDSCH) | [+] - 85.416 | - 1.704 | .088 |
| $D_4$ | (MEDCRE) | [+] - 78.281 | - 2.308 | .022 |
| L/K | (PNLSIZ) | 243.520 | 13.536 | .000+ |
| P | (DWAGE) | 29.993 | 11.954 | .000+ |
| X | (COMPT) | 4.255 | 1.992 | .047 |
| Stepwise Procedure, $R^2$: .88904 | | | | |
| Intercept | | 193.553 | - | - |
| $M_{14}$ | (DRD) | 25.727 | 2.106 | .035 |
| $M_{31}$ | (EMR) | [+] - 27.245 | - 2.047 | .041 |
| $E_2$ | (ADBED) | - 10.288 | -17.627 | .000+ |
| $E_3$ | (BBASS) | - 1.251 | - 3.120 | .003 |

TABLE IV (Continued)

| Variables found by procedure | | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater $\|t\|$ |
|---|---|---|---|---|
| $D_4$ | (MEDCRE) | [+] - 66.360 | - 2.129 | .034 |
| L/K | (PNLSIZ) | 233.614 | 15.864 | .000+ |
| P | (DWAGE) | 27.226 | 12.293 | .000+ |
| X | (COMPT) | 4.348 | 2.306 | .022 |

*Expected signs are indicated in brackets.

The study's hypothesis gains considerable support from the results of these analyses. The coefficient of COMPT is positive in both models and is statistically significant at the 5 percent level in both. This is a substantial gain in support over the barely suggestive results of the regression of the "complete" model on CPAD. Given the modest loss in $R^2$ between these models and the 48 variable model, there is some confirmation that irrelevant variables were eliminated with these procedures.

Partial joint tests of the hypothesis that the coefficients of deleted variables were not different from zero produced "F" statistics that were not significant.[2] The hypothesis, therefore, was accepted. There may be some question regarding the importance of the variables deleted from the Forward Selection results by the Stepwise routine. A partial joint test was performed and the calculated "F" statistic was not quite significant at the 5 percent level indicating that the deleted regressors might not be important in explaining the behavior of CPAD, i.e., that the

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[2]For the Forward Selection model,

$$F = \frac{(.92466-.91149) \div 28}{(1-.92466) \div (107-48-1)} = .36208;$$

and in the Stepwise model,

$$F = \frac{(.92466-.88904) \div 40}{(1-.92466) \div (107-48-1)} = .68588.$$

"smaller" model is "better."[3] This test is appropriate in this instance as all the regressors found by the Stepwise routine were also found by the Forward Selection routine. If, however, the "smaller" model had regressors not in the "larger" model, this partial joint test would not be appropriate.

When the Forward Selection and Stepwise routines were performed with CPPD as the dependent variable, the resulting models contained 23 and 8 independent variables respectively. These results appear in Table V. Again, there are conflicts between the results and the expected signs of some of the regression coefficients.

The magnitudes, signs, and test statistics of the coefficients of COMPT in both resulting models offer strong evidence in support of the study's central hypothesis. The level of significance for the coefficient of COMPT is 2.32 percent in the Forward Selection model and 0.12 percent in the Stepwise model. These results are even more encouraging given the very small loss in explanatory power of these models from that of the regression of the "complete" model. The results of the partial joint tests justify these

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3 $$F = \frac{(.91149-.88904) \div 12}{(1-.91149) \div (107-20-1)} = 1.81790.$$

TABLE V

REGRESSION RESULTS: FORWARD SELECTION AND STEPWISE PROCEDURES FOR DEPENDENT VARIABLE CPPD*

| Variables found by procedure | | | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater \|t\| |
|---|---|---|---|---|---|
| | | | Forward Selection Procedure, $R^2$: .87925 | | |
| Intercept | | | 81.725 | - | - |
| $M_1$ | (CANCER) | | 7.781 | 1.629 | .103 |
| $M_5$ | (RECOV) | | - 2.601 | - 6.696 | .090 |
| $M_6$ | (ICU) | | 3.172 | 1.920 | .055 |
| $M_7$ | (ICCU) | [+] | - 0.813 | - 0.616 | .553 |
| $M_8$ | (OHS) | [+] | - 6.525 | - 1.671 | .095 |
| $M_{11}$ | (XRT) | [+] | - 6.558 | - 2.775 | .007 |
| $M_{14}$ | (DRD) | | 4.813 | 2.184 | .030 |
| $M_{16}$ | (PATH) | | 3.125 | 1.427 | .154 |
| $M_{17}$ | (BLBK) | | - 1.900 | - 1.333 | .183 |
| $M_{21}$ | (SCU) | | - 4.795 | - 1.575 | .115 |
| $M_{23}$ | (PHTH) | | 0.378 | 0.225 | .817 |
| $M_{27}$ | (REHO) | [+] | - 5.268 | - 1.136 | .258 |
| $M_{30}$ | (OPD) | | 4.837 | 2.173 | .031 |
| $M_{31}$ | (EMR) | [+] | - 4.893 | - 2.533 | .003 |
| $E_1$ | (ORATE) | | - 0.409 | - 2.636 | .009 |
| $E_2$ | (ADBED) | | - 0.879 | - 3.134 | .003 |
| $E_3$ | (BBASS) | | - 0.183 | - 3.133 | .003 |
| $E_4$ | (LSTAY) | | - 5.771 | - 4.201 | .000+ |
| $D_3$ | (BCROSS) | [+] | - 8.198 | - 1.280 | .201 |
| $D_4$ | (MEDCRE) | [+] | -11.607 | - 2.192 | .029 |
| L/K | (PNLSIZ) | | 36.361 | 11.392 | .000+ |
| P | (DWAGE) | | 3.974 | 11.727 | .000+ |
| X | (COMPT) | | 0.715 | 2.288 | .023 |
| | | | Stepwise Procedure, $R^2$: .83983 | | |
| Intercept | | | 55.413 | - | - |
| $E_1$ | (ORATE) | | - .338 | - 2.365 | .019 |

TABLE V (Continued)

| Variables found by procedure | | | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater $\lvert t \rvert$ |
|---|---|---|---|---|---|
| $E_2$ | (ADBED) | | - .817 | - 3.087 | .003 |
| $E_3$ | (BBASS) | | - .173 | - 2.981 | .004 |
| $E_4$ | (LSTAY) | | - 5.268 | - 4.015 | .000+ |
| $M_{31}$ | (EMR) | [+] | - 4.384 | - 2.333 | .026 |
| L/K | (PNLSIZ) | | 33.179 | 14.203 | .000+ |
| P | (DWAGE) | | 3.927 | 12.597 | .000+ |
| X | (COMPT) | | .940 | 3.436 | .001 |

*Expected signs are indicated in brackets.

reductions in the numbers of independent variables.[4] It was again found that it was appropriate to test the hypothesis that the coefficients of the regressors deleted from the Forward Selection model by the Stepwise model are irrelevant in explaining the behavior of the dependent variable. In this instance, the "F" statistic was just significant at the 5 percent level and the hypothesis was rejected.[5]

These results strongly support the study's central hypothesis and offer substantial justification for restricting the analysis to models containing fewer than the 48 independent variables indicated in Equation (2). However, no attempt is made to select "best" models other than to imply that the "best" models contain fewer than 48 regressors.

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[4]For the Forward Selection model,

$$F = \frac{(.89387-.87925) \div 25}{(1-.89387) \div (107-48-1)} = .31960;$$

and for the Stepwise model,

$$F = \frac{(.89387-.83983) \div 40}{(1-.89387) \div (107-48-1)} = .73833.$$

[5]

$$F = \frac{(.87925-.83983) \div 15}{(1-.87925) \div (107-23-1)} = 1.80643.$$

## Sequential Model Construction Results: The "Maximum $R^2$ Improvement" Technique

Both versions of the model were fitted to the data using the S. A. S. Maximum $R^2$ Improvement technique. Since there was evidence that COMPT was important in very "small" as well as in "larger" models in explaining the variation in average cost, it is desirable to observe the behavior of the coefficient of COMPT and its test statistics in models containing various numbers of independent variables. There is little reason to be concerned with models containing large numbers of regressors given the results and tests of other regression procedures. Therefore, the Maximum $R^2$ procedure was terminated after all regressions on from 1 through 30 independent variables were computed for both versions of the model. An abbreviated summary of these results is given in Table VI. The sign of the coefficient of COMPT was uniformly positive whenever COMPT appeared as an important variable "found" by the procedure. Since the purpose of this procedure is only to develop further argument concerning the study's central hypothesis, the other variables "found" by Maximum $R^2$ Improvement are not presented in Table VI. Therefore, only the $R^2$ statistics for each model and the coefficients of COMPT, their t-scores, and their significance levels are furnished in Table VI.

In the case where CPAD is the dependent variable, when COMPT first appears in a model, its coefficient is positive

TABLE VI

REGRESSION RESULTS: MAXIMUM $R^2$ IMPROVEMENT TECHNIQUE

| Number of variables in model | $R^2$ | Coefficient of COMPT (b values) | t-Scores for $H_o$: b = 0 | Prob. of a greater \|t\| |
|---|---|---|---|---|
| | | Dependent Variable CPAD | | |
| 1 | .31909 | - | - | - |
| 2 | .51825 | - | - | - |
| 3 | .86012 | - | - | - |
| 4 | .86771 | - | - | - |
| 5 | .87538 | - | - | - |
| 6 | .88016 | 4.408 | 2.280 | .023 |
| 7 | .88429 | 4.386 | 2.297 | .022 |
| 8 | .88904 | 4.348 | 2.306 | .022 |
| 9 | .89111 | 4.320 | 2.301 | .022 |
| 10 | .89467 | 4.154 | 2.235 | .026 |
| 11 | .89748 | 4.107 | 2.228 | .027 |
| 12 | .89986 | 3.358 | 1.779 | .075 |
| 13 | .90159 | 2.938 | 1.538 | .123 |
| 14 | .90358 | 3.222 | 1.716 | .086 |
| 15 | .90496 | 3.296 | 1.757 | .079 |
| 16 | .90675 | 3.311 | 1.586 | .112 |
| 17 | .90844 | 3.525 | 1.689 | .091 |
| 18 | .90962 | 3.724 | 1.779 | .075 |
| 19 | .91056 | 3.902 | 1.856 | .064 |
| 20 | .91149 | 4.255 | 1.992 | .047 |
| 21 | .91279 | 2.983 | 1.388 | .165 |
| 22 | .91389 | 2.874 | 1.336 | .182 |
| 23 | .91475 | 3.186 | 1.461 | .144 |
| 24 | .91557 | 2.831 | 1.276 | .203 |
| 25 | .91688 | 3.034 | 1.374 | .170 |
| 26 | .91778 | 3.338 | 1.495 | .135 |
| 27 | .91841 | 3.585 | 1.585 | .113 |

TABLE VI (Continued)

| Number of variables in model | $R^2$ | Coefficient of COMPT (b values) | t-Scores for $H_o$: b = 0 | Prob. of a greater $\|t\|$ |
|---|---|---|---|---|
| 28 | .91904 | 3.186 | 1.371 | .171 |
| 29 | .91960 | 3.614 | 1.504 | .133 |
| 30 | .92050 | 2.824 | 1.188 | .237 |
| | | Dependent Variable CPPD | | |
| 1 | .33025 | - | - | - |
| 2 | .53369 | - | - | - |
| 3 | .76776 | - | - | - |
| 4 | .78415 | 0.838 | 2.783 | .007 |
| 5 | .79887 | 0.841 | 2.878 | .005 |
| 6 | .82512 | 0.875 | 3.114 | .003 |
| 7 | .83315 | 0.887 | 3.214 | .002 |
| 8 | .83983 | 0.940 | 3.436 | .001 |
| 9 | .84405 | 0.928 | 3.418 | .001 |
| 10 | .84760 | 0.907 | 3.358 | .002 |
| 11 | .85364 | 0.879 | 3.280 | .002 |
| 12 | .85767 | 0.884 | 3.328 | .002 |
| 13 | .86035 | 0.828 | 3.089 | .003 |
| 14 | .86356 | 0.760 | 2.815 | .006 |
| 15 | .86560 | 0.714 | 2.622 | .010 |
| 16 | .86913 | 0.907 | 3.018 | .004 |
| 17 | .87139 | 0.901 | 3.009 | .004 |
| 18 | .87346 | 0.872 | 2.908 | .005 |
| 19 | .87528 | 0.867 | 2.896 | .005 |
| 20 | .87666 | 0.894 | 2.973 | .004 |
| 21 | .87826 | 0.895 | 2.955 | .004 |
| 22 | .88009 | 0.894 | 2.959 | .004 |
| 23 | .88119 | 0.884 | 2.840 | .006 |
| 24 | .88242 | 0.861 | 2.758 | .007 |
| 25 | .88445 | 0.749 | 2.382 | .019 |

TABLE VI (Continued)

| Number of variables in model | $R^2$ | Coefficient of COMPT (b values) | t-Scores for $H_o$: b = 0 | Prob. of a greater $\|t\|$ |
|---|---|---|---|---|
| 26 | .88571 | 0.758 | 2.408 | .017 |
| 27 | .88695 | 0.689 | 2.165 | .031 |
| 28 | .88814 | 0.699 | 2.194 | .029 |
| 29 | .88933 | 0.676 | 2.113 | .036 |
| 30 | .88980 | 0.696 | 2.152 | .033 |

and statistically significant and remains so through 5 additional models (6 through 11 independent variables); it does not become statistically significant again until the 20-variable model although it remains positive throughout. It is interesting to note that the 8 and 20 variable models found with this technique are the identical models found by the Stepwise and the Forward Selection procedures. Even though the coefficient of COMPT was not statistically significant in any larger models, COMPT was included as one of the "important" variables in all larger models found by the Maximum $R^2$ Improvement technique (until, of course, the routine was terminated at 30 independent variables). The positive sign of the coefficients of COMPT and the behavior of the tests of statistical significance again provide substantial argument in support of the study's central hypothesis.

In the case where CPPD is the dependent variable, COMPT enters the Maximum $R^2$ routine with the 4 variable model. The coefficient of COMPT is statistically significant at the 1.0 percent level and remains so through the 24 variable model. In the remaining 25 through 30 variable models, the significance level never rises to as much as 4.0 percent. The 8 variable model found by Maximum $R^2$ is identical to that found by Stepwise; the 23 variable model, however, is a little different from that found by Forward Selection. Maximum $R^2$ eliminated ICCU, PHTH, and REHO from the Forward Selection model and substituted RDT, PREM, and ECEP. This change raised $R^2$ from .87925 to .88119. Otherwise, the models are identical. There hardly needs be comment regarding the support these results give the study's hypothesis. The signs, magnitudes, and test statistics of the coefficient of COMPT in all models larger than three independent variables are powerful supporting argument.

The Maximum $R^2$ Improvement technique first chose COMPT to enter the 6-variable model for the dependent variable CPAD, and the 4-variable model for the dependent variable CPPD. Partial joint tests were performed regarding the addition of COMPT at these points in the Maximum $R^2$ routines.[6] The resulting "F" statistics were significant in both instances indicating that the addition of COMPT to these very "small" models added little to the explanatory power of the regressions. These results conflict with the test statistics on the coefficient of COMPT in both instances, however. This test does offer some contrary argument regarding the study's hypothesis.

---

[6]When CPAD is the dependent variable,

$$F = \frac{(.88016-.87538) \div 1}{(1-.88016) \div (107-6-1)} = 3.98865;$$

and when CPPD is the dependent variable,

$$F = \frac{(.78415-.76776) \div 1}{(1-.78415) \div (107-4-1)} = 7.74538.$$

## Regression Results: Tests for Interactions

The quadratic form of COMPT and the other seven interaction variables were added to the set of independent variables in both forms of Equation (2).[7] These larger sets of independent variables were analyzed by means of the Forward Selection, Stepwise, and Maximum $R^2$ Improvement stepwise regression procedures. For these purposes, the Maximum $R^2$ routine was terminated after the 20-variable model was found and fit.

In the case where CPAD was the dependent variable, none of the above stepwise regression procedures selected COMPT or its quadratic form for any model. However, the interaction of COMPT and BBASS (CM_BS) appeared uniformly in all but the models containing fewer than six independent variables. Where BBASS was selected, its coefficient was significant and was negative as expected but the interaction variable, CM_BS, had a positive coefficient that was statistically significant whenever it appeared. These results are summarized in Tables VII and VIII. In the Forward Selection results and in the Maximum $R^2$ results beginning with the 13-variable model, another interaction variable, COMPT with ADMD (CM_AM), appears in the models. Its coefficient is uniformly negative and statistically significant in all

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[7]The identification of the interaction variables is given above, p. 61.

TABLE VII

REGRESSION RESULTS: TESTS FOR INTERACTIONS, FORWARD SELECTION AND STEPWISE PROCEDURES FOR DEPENDENT VARIABLE CPAD*

| Variables found by procedure | | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater $\|t\|$ |
|---|---|---|---|---|
| | | Forward Selection Procedure, $R^2$: .91638 | | |
| Intercept | | 183.086 | - | - |
| $Q_1$ | (ADMD) | [-] 0.292 | 0.275 | .780 |
| $M_2$ | (RESI) | 53.602 | 1.829 | .068 |
| $M_4$ | (NURSE) | 64.239 | 2.471 | .015 |
| $M_5$ | (RECOV) | - 12.473 | - 1.189 | .236 |
| $M_6$ | (ICU) | 17.650 | 1.617 | .106 |
| $M_7$ | (ICCU) | [+]- 8.167 | - 0.912 | .633 |
| $M_{11}$ | (XRT) | [+]- 48.932 | - 2.901 | .005 |
| $M_{14}$ | (DRD) | 33.519 | 2.216 | .028 |
| $M_{22}$ | (EXCU) | [+]- 21.535 | - 1.093 | .277 |
| $M_{29}$ | (PSYE) | 43.582 | 2.197 | .029 |
| $M_{30}$ | (OPD) | 30.093 | 2.050 | .041 |
| $M_{31}$ | (EMR) | [+]- 28.521 | - 2.146 | .033 |
| $M_{33}$ | (HAX) | [-] 10.466 | 1.126 | .262 |
| $E_1$ | (ORATE) | - 1.055 | - 1.031 | .306 |
| $E_2$ | (ADBED) | - 7.855 | - 4.086 | .000+ |
| $E_3$ | (BBASS) | - 1.855 | - 3.786 | .000+ |
| $E_4$ | (LSTAY) | 6.549 | 0.707 | .512 |
| $D_4$ | (MEDCRE) | [+]- 98.390 | - 2.916 | .005 |
| L/K | (PNLSIZ) | 228.892 | 12.334 | .000+ |
| P | (DWAGE) | 27.020 | 11.676 | .000+ |
| CM_AM | | - 0.331 | - 2.228 | .027 |
| CM_BS | | 0.198 | 2.694 | .008 |
| | | Stepwise Procedure, $R^2$: .890986 | | |
| Intercept | | 198.281 | - | - |
| $M_{14}$ | (DRD) | 29.493 | 2.459 | .015 |

TABLE VII (Continued)

| Variables found by procedure | | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater $\|t\|$ |
|---|---|---|---|---|
| $M_{31}$ | (EMR) | [+]- 28.690 | - 2.172 | .030 |
| $E_2$ | (ADBED) | - 10.091 | -17.165 | .000+ |
| $E_3$ | (BBASS) | - 1.551 | - 3.608 | .001 |
| $D_4$ | (MEDCRE) | [+]- 69.561 | - 2.248 | .025 |
| L/K | (PNLSIZ) | 231.499 | 15.755 | .000+ |
| P | (DWAGE) | 27.363 | 12.518 | .000+ |
| CM_BS | | 0.112 | 2.654 | .009 |

*Expected signs are indicated in brackets.

TABLE VIII

REGRESSION RESULTS: TESTS FOR INTERACTIONS, MAXIMUM $R^2$ IMPROVEMENT PROCEDURE FOR DEPENDENT VARIABLE CPAD

| Number of variables in model | $R^2$ | Competition and interaction variables found by procedure | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater $\|t\|$ |
|---|---|---|---|---|---|
| 1 | .31909 | - | - | - | - |
| 2 | .51825 | - | - | - | - |
| 3 | .86012 | - | - | - | - |
| 4 | .86771 | - | - | - | - |
| 5 | .87538 | - | - | - | - |
| 6 | .88086 | CM_BS | 0.105 | 2.412 | .017 |
| 7 | .88543 | CM_BS | 0.108 | 2.511 | .013 |
| 8 | .88841 | CM_BS | 0.105 | 2.470 | .015 |
| 9 | .89334 | CM_BS | 0.110 | 2.623 | .009 |
| 10 | .89614 | CM_BS | 0.106 | 2.536 | .012 |
| 11 | .89930 | CM_BS | 0.110 | 2.662 | .009 |
| 12 | .90210 | CM_BS | 0.097 | 2.320 | .021 |
| 13 | .90468 | CM_AM | -0.282 | -2.255 | .025 |
| | | CM_BS | 0.197 | 3.002 | .004 |
| 14 | .90787 | CM_AM | -0.281 | -2.273 | .024 |
| | | CM_BS | 0.197 | 3.034 | .004 |

TABLE VIII (Continued)

| Number of variables in model | $R^2$ | Competition and interaction variables found by procedure | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater \|t\| |
|---|---|---|---|---|---|
| 15 | .90966 | CM_AM | -0.292 | -2.366 | .019 |
| | | CM_BS | 0.200 | 3.086 | .003 |
| 16 | .91140 | CM_AM | -0.318 | -2.555 | .012 |
| | | CM_BS | 0.207 | 3.206 | .002 |
| 17 | .91301 | CM_AM | -0.317 | -2.560 | .012 |
| | | CM_BS | 0.195 | 2.999 | .004 |
| 18 | .91447 | CM_AM | -0.312 | -2.527 | .013 |
| | | CM_BS | 0.194 | 2.983 | .004 |
| 19 | .91547 | CM_AM | -0.328 | -2.634 | .010 |
| | | CM_BS | 0.198 | 3.047 | .003 |
| 20 | .91614 | CM_AM | -0.325 | -2.604 | .011 |
| | | CM_BS | 0.195 | 2.990 | .004 |

models. Whenever these two interactions appear together in a model, the impact of COMPT on average cost can only be determined on a hospital-by-hospital basis with actual values for BBASS and ADMD. If, however, one chooses mean values for BBASS (23.37) and ADMD (9.72), it can be shown that COMPT has a positive impact on average cost in all models whether CM_BS appears alone or with CM_AM.

Where CPPD was the dependent variable, the procedures selected COMPT alone, in combination with its quadratic form, and in various combinations with other interaction variables as well as selecting only interaction variables in various models. These results are summarized in Tables IX and X. Two interaction variables with negative coefficients, COMPT with LSTAY (CM_LS) and COMPT with PNLSIZ (CM_PZ), appear in combination with COMPT or in combination with other interaction variables in three different models, the Forward Selection model and the 5- and 6-variable Maximum $R^2$ models. Again, there are problems regarding the measurement of the impact of COMPT on average cost. But as before, if one chooses mean values for ORATE (67.07), LSTAY (6.92), and PNLSIZ (1.61), it can be shown that COMPT has a positive impact on average cost in all models.

These results add some support for the study's hypothesis that is developed above. In particular, the results of the tests for interactions for the dependent variable CPPD add yet stronger supporting argument in that the Maximum $R^2$ procedure (Table X), even with eight more

TABLE IX

REGRESSION RESULTS: TESTS FOR INTERACTIONS, FORWARD SELECTION AND STEPWISE PROCEDURES FOR DEPENDENT VARIABLE CPPD*

| Variables found by procedure | | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater \|t\| |
|---|---|---|---|---|
| | | Forward Selection Procedure, $R^2$: .87394 | | |
| Intercept | | 71.980 | - | - |
| $M_7$ | (ICCU) | [+] - 1.423 | - 1.144 | .254 |
| $M_{11}$ | (XRT) | [+] - 4.902 | - 2.245 | .026 |
| $M_{14}$ | (DRD) | 3.570 | 1.747 | .080 |
| $M_{29}$ | (PSYE) | 5.718 | 1.801 | .072 |
| $M_{30}$ | (OPD) | 3.823 | 1.800 | .072 |
| $M_{31}$ | (EMR) | [+] - 3.588 | - 1.852 | .064 |
| $M_{33}$ | (HAX) | [-] 1.931 | 1.393 | .164 |
| $E_1$ | (ORATE) | - 0.270 | - 1.631 | .103 |
| $E_2$ | (ADBED) | - 1.045 | - 3.489 | .001 |
| $E_3$ | (BBASS) | - 0.155 | - 2.587 | .011 |
| $E_4$ | (LSTAY) | - 6.365 | - 4.469 | .000+ |
| $D_1$ | (ACCR) | [+] - 2.241 | - 1.296 | .198 |
| $D_4$ | (MEDCRE) | [+] - 8.915 | - 1.731 | .083 |
| L/K | (PNLSIZ) | 34.050 | 12.764 | .000+ |
| P | (DWAGE) | 4.013 | 10.714 | .000+ |
| X | (COMPT) | 6.967 | 2.878 | .005 |
| COM_2 | | - 0.193 | - 1.113 | .268 |
| CM_PZ | | - 0.449 | - 0.780 | .556 |
| CM_LS | | - 0.528 | - 2.235 | .026 |
| | | Stepwise Procedure, $R^2$: .84705 | | |
| Intercept | | 58.900 | - | - |
| $M_{31}$ | (EMR) | [+] - 4.048 | - 2.405 | .017 |
| $E_1$ | (ORATE) | - 0.341 | - 2.431 | .016 |
| $E_2$ | (ADBED) | - 0.801 | - 3.080 | .003 |
| $E_3$ | (BBASS) | - 0.176 | - 3.085 | .003 |

TABLE IX (Continued)

| Variables found by procedure | | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater $\|t\|$ |
|---|---|---|---|---|
| $E_4$ | (LSTAY) | - 5.388 | - 4.177 | .000+ |
| L/K | (PNLSIZ) | 32.645 | 14.143 | .000+ |
| P | (DWAGE) | 3.743 | 11.767 | .000+ |
| X | (COMPT) | 4.048 | 2.740 | .007 |
| COM_2 | | - 0.341 | - 2.140 | .033 |

*Expected signs are indicated in brackets.

# TABLE X

REGRESSION RESULTS: TESTS FOR INTERACTIONS, MAXIMUM $R^2$ IMPROVEMENT PROCEDURE FOR DEPENDENT VARIABLE CPPD

| Number of variables in model | $R^2$ | Competition and interaction variables found by procedure | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater $\lvert t \rvert$ |
|---|---|---|---|---|---|
| 1 | .33025 | - | - | - | - |
| 2 | .53369 | - | - | - | - |
| 3 | .76776 | - | - | - | - |
| 4 | .78415 | X (COMPT) | 0.838 | 2.783 | .007 |
| 5 | .80380 | X (COMPT) | 4.678 | 3.768 | .001 |
| | | CM_PZ | -1.830 | -3.180 | .002 |
| 6 | .81433 | CM_OR | 0.054 | 3.475 | .001 |
| | | CM_PZ | -1.693 | -2.882 | .005 |
| 7 | .83402 | CM_AB | 0.021 | 3.302 | .002 |
| 8 | .84125 | CM_AB | 0.021 | 3.430 | .001 |
| 9 | .84498 | CM_AB | 0.020 | 3.172 | .002 |
| 10 | .84846 | CM_AB | 0.020 | 3.194 | .002 |
| 11 | .85221 | CM_AB | 0.020 | 3.169 | .002 |
| 12 | .85778 | CM_AB | 0.020 | 3.341 | .002 |
| 13 | .86067 | CM_AB | 0.019 | 3.127 | .003 |
| 14 | .86372 | CM_DW | 0.053 | 2.835 | .006 |

TABLE X (Continued)

| Number of variables in model | $R^2$ | Competition and interaction variables found by procedure | Coefficients (b values) | t-Scores for $H_o$: b = 0 | Probability of a greater $\|t\|$ |
|---|---|---|---|---|---|
| 15 | .86564 | CM_DW | 0.050 | 2.628 | .009 |
| 16 | .86913 | X (COMPT) | 0.907 | 3.018 | .004 |
| 17 | .87147 | CM_DW | 0.064 | 3.018 | .004 |
| 18 | .87346 | X (COMPT) | 0.872 | 2.908 | .005 |
| 19 | .87528 | X (COMPT) | 0.867 | 2.896 | .005 |
| 20 | .87666 | X (COMPT) | 0.894 | 2.973 | .004 |

variables to select from, found several models that are identical to previous results. It is, however, unknown what might be the extent or importance of untested interactions among independent variables in Equation (2).

This section has tested for and found statistically significant interactions between the variable COMPT and other determinants of average cost. The results are in substantial agreement with the results of the other analyses.

## Results of a Factor Analysis of the Determinants of Average Cost

The independent variables specified in Equation (2) were subjected to a factor analysis to gain some insights regarding the groupings of those variables to represent (1) hospital output, (2) the multiproduct nature of output, (3) the efficiency of production, (4) the quality of output, and other determinants of average cost. The S. A. S. Factor procedure was instructed to limit the number of factors to eight. This number is a bit arbitrary but seemed adequate given the categories in Equation (2).

The "rotated factor matrix" from the output of the S. A. S. Factor procedure is used in the analysis developed here. After being factored, all independent variables in Equation (2) were assigned to particular factors on the criterion that the variable had its highest "factor loading" (or correlation) with a particular factor. These results are given in Table XI.

TABLE XI

RESULTS OF A FACTOR ANALYSIS OF THE DETERMINANTS OF AVERAGE COST*

| | Variables | | Factor Loadings |
|---|---|---|---|
| | $Q_1$ | (ADMD) | .75 |
| | $(Q_1)^2$ | (ADM_2) | .84 |
| | $Q_2$ | (CENSUS) | .78 |
| | $(Q_2)^2$ | (CEN_2) | .85 |
| | $M_2$ | (RESI) | .84 |
| | $M_3$ | (INTERN) | .84 |
| | $M_4$ | (NURSE) | .43 |
| | $M_8$ | (OHS) | .68 |
| Factor 1 | $M_{11}$ | (XRT) | .72 |
| | $M_{12}$ | (CBT) | .80 |
| | $M_{13}$ | (RDT) | .80 |
| | $M_{14}$ | (DRD) | .54 |
| | $M_{15}$ | (TRD) | .84 |
| | $M_{18}$ | (ECEP) | .48 |
| | $M_{23}$ | (RENI) | .78 |
| | $M_{24}$ | (RENO) | .72 |
| | $M_{26}$ | (OCTH) | .54 |
| | $M_{28}$ | (PSYI) | .66 |
| | $D_2$ | (MEDSCH) | .81 |
| | $M_5$ | (RECOV) | .59 |
| | $M_6$ | (ICU) | .60 |
| | $M_9$ | (FTP) | .64 |
| Factor 2 | $M_{16}$ | (PATH) | .66 |
| | $M_{17}$ | (BLBK) | .36 |
| | $M_{19}$ | (IHTH) | .75 |
| | $M_{20}$ | (PREM) | .49 |
| | $M_{25}$ | (PHTH) | .75 |
| | $M_{29}$ | (PSYE) | .37 |

TABLE XI (Continued)

| | Variables | | Factor Loadings |
|---|---|---|---|
| Factor 2 (Continued) | $M_{33}$ | (HAX) | .42 |
| | L/K | (PNLSIZ) | .59 |
| Factor 3 | $M_{22}$ | (EXCU) | .47 |
| | $E_1$ | (ORATE) | -.65 |
| | $E_2$ | (ADBED) | -.82 |
| | $E_3$ | (BBASS) | -.53 |
| | $E_4$ | (LSTAY) | .47 |
| | X | (COMPT) | -.43 |
| Factor 4 | $M_7$ | (ICCU) | .59 |
| | $M_{21}$ | (SCU) | .55 |
| | $M_{30}$ | (OPD) | .57 |
| | $M_{31}$ | (EMR) | .43 |
| | $M_{34}$ | (VLS) | .54 |
| Factor 5 | PM | | -.57 |
| | $D_4$ | (MEDCRE) | .84 |
| Factor 6 | $M_1$ | (CANCER) | .79 |
| | $M_{27}$ | (REHO) | .69 |
| | $M_{32}$ | (SWD) | .57 |
| Factor 7 | $D_1$ | (ACCR) | -.63 |
| | P | (DWAGE) | -.56 |
| Factor 8 | $M_{10}$ | (PTP) | -.63 |
| | $D_3$ | (BCROSS) | .42 |

*All factor loadings are from the rotated factor matrix of the analysis.

Meaningful identification of factors from the results of a factor analysis is not always possible. However, the results presented in Table XI are readily identified in the cases of factors 1, 2, 3, and 4 and are identified more tentatively in the cases of the other factors. Factors 1, 2, 4, and 6 can be said to represent the multiproduct nature of hospital output. Factor 1 represents output associated with large hospitals with large admissions and patient populations, i.e., high output hospitals; factor 2 represents basic services and staffing; factor 4 might be outpatient and emergency services; and factor 6 might represent that hospital output that is associated with seriously ill or injured patients requiring long recuperation times. Factor 3 is, of course, the efficiency of hospital output and factors 5, 7, and 8 can be interpreted as representing the quality of hospital output.

Given the rather small number of hospitals in the set of observations, these results offer remarkable justification for the rather subjective criteria applied to group the independent variables in Equation (2) to represent the determinants of average cost detailed in Equation (1). The theoretical soundness of the cost relationship is reinforced by these results.

## Summary

This chapter has presented the results of the analysis of the data and the test of the study's central hypothesis.

The multiple regression analyses and the associated sequential methods developed or "found" several models or cost prediction equations that explained substantial proportions of the variation in the average cost of hospital output with considerably fewer independent variables than those specified in Equation (2). These smaller or more compact models almost always contained the dependent variable COMPT that represented the degree or intensity of competition, the subject of interest in this study. The multiple regression coefficient for COMPT estimated by these procedures was uniformly positive and this positive sign was consistent with the study's central hypothesis. And the tests of statistical significance on the coefficient of COMPT indicate that it is an "important" variable in explaining the behavior of average cost. The results of the factor analyses of the determinants of average cost justify the formulation and specification of the cost function described by Equation (1) and the statistical model described by Equation (2).

# CHAPTER VI

# SUMMARY OF FINDINGS, CONCLUSIONS, AND IMPLICATIONS

## Introduction

The first section of this chapter summarizes the findings and discusses the conclusions derived from the preceding empirical chapter. The results of the analyses and tests are compared with the central hypothesis and the purpose of the study. This section also includes some discussion regarding the usefulness of the smaller models found by the sequential model construction methods to predict average cost of production in hospitals. The last section of the chapter discusses the implications of the findings and the need for further investigation suggested by the study.

## Summary and Conclusions

It was mentioned in Chapter IV that both linear and quadratic forms of the measures of output were included in Equation (2) in order to test the assumption of the "U" shapedness of the resulting average cost curves. In the few models where either ADMD or CENSUS were in the sets of regressors, the signs of their coefficients were negative, indicating economies of size. The quadratic forms of the measures of output never appeared without the linear measures also being in the sets of regressors. In the analyses discussed here, this occurred only in the 48 regressor models. It is noted in the CPAD results that the coefficient of ADMD is negative and that the coefficient of ADM_2 is positive; in the CPPD model the coefficient of CENSUS is negative and the coefficient of CEN_2 is positive.[1] These results define a "U" shaped average cost curve with respect to output. None of these coefficients are statistically significant at even the 50 percent level. Using the CPPD results and assuming that all other regressors and their coefficients are constants, the derivative of average cost (CPPD) with respect to output (CENSUS) is:

$$\frac{d\ (CPPD)}{d\ (CENSUS)} = .00005\ (CENSUS) - .039.$$

Setting this derivative equal to zero and solving for CENSUS at the minimum value of CPPD yields:

$$CENSUS = \frac{.039}{.00005} = 780,$$

indicating that minimum average cost is not reached until very large daily patient census counts are reached. Similar conclusions are obtained with the CPAD model. These results indicate that economies of size exist in this industry

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[1]See Table III, pp. 71-73.

through very large hospitals. However, the levels of significance associated with output variables degrade this conclusion.

There is considerable discussion in earlier chapters concerning the effects of profit incentives on the average cost of hospital output. The literature argues that costs should be lower in for-profit hospitals. This study argues that responses of hospitals to satisfy the wants of their physician-customers will be similar in either for-profit or in nonprofit hospitals. The profit motive variable appeared only in the 48 independent variable models. Its coefficient was positive in both models but was not statistically significant in either.[2] These results provide weak support for this study's argument.

The results of the analyses of the 48 variable models specified in Equation (2) were only suggestive regarding the hypothesized effect of competition on average cost. However, it was not expected that analyses of such cumbersome equations would have resulted in support for the hypothesis. Nevertheless, the analysis of the model with CPPD as the dependent variable produced a coefficient for COMPT that was positive and with a significance level of less than 10 percent. The results with CPAD as the dependent variable were not nearly so suggestive; the coefficient of COMPT was positive but with a significance level of only 65 percent.[3]

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[2] Ibid.

[3] Ibid.

The sequential model construction methods employed to reduce the number of independent variables found a number of models that were more amenable to analysis. The analyses of these models produced rather overwhelming support for the study's hypothesis. Whenever COMPT was selected as one of the independent variables in these models, its coefficient was uniformly positive and statistically significant in most.

The Forward Selection procedure found 20 variables for the CPAD model and 23 variables for the CPPD model. The coefficient of COMPT was 4.255 in the CPAD model and 0.715 in the CPPD model. These coefficients were significant at the .047 and the .023 levels respectively.[4] This indicates that an additional competitor in a market adds about $4.26 to an admission and about $.72 to a day of care in hospitals in that market. Each of these results is in reasonable agreement with the other. The Stepwise procedure found eight variables for both the CPAD and the CPPD versions. The coefficients of COMPT were 4.348 and 0.940 with significance levels of .022 and .001 for CPAD and CPPD respectively.[5] Again, the results are consistent one with the other. To compare the coefficients in the CPPD models to those in the CPAD models requires that the mean value of "length of stay" (6.9 days) be used as a multiplier for the coefficients in the CPPD models. This produces values that

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[4]See Tables IV and V, pp. 76 and 80.

[5]Ibid.

are different from the coefficients in the CPAD models. These differences are quite modest when the standard errors of the coefficients and the standard deviation of the mean of LSTAY are considered. The magnitudes of the coefficients of COMPT indicate that even small numbers of competitors in a market would cause average cost to be substantially higher.

The Maximum $R^2$ Improvement technique found all 1 through 30 independent variable models that were "best" models based on the criterion of producing the highest $R^2$ values. In the 1 to 5 independent variable models with CPAD as the dependent variable, Maximum $R^2$ did not select COMPT but included it thereafter through the 30 variable model. The statistical significance of the coefficient of COMPT remained below 3 percent from the 6 through the 11 variable model. In the other 13 through 30 variable models, the significance level ranged from a little less than 8 percent to a little over 24 percent with the exception of the 20 variable where the significance dropped to less than 5 percent.[6] The Maximum $R^2$ results with CPPD as the dependent variable selected COMPT beginning with the 4 variable model and included it in all subsequent models. The coefficient was significant at the 1 percent level through the 24 variable model and the

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[6]See Table VI, pp. 84-86.

significance level never rose to as much as 4 percent through the 30 variable model.[7]

The conclusions derived from these results are that higher degrees of or more intense competition in the hospital industry results in higher average cost of production. These conclusions do not depend on the particular measure of output selected by the investigator. These results indicate that the study's central hypothesis can be accepted and that the purpose of the study is satisfied.

The conclusions arising from the tests for interactions between COMPT and other variables are discussed in Chapter V. There was, however, a secondary purpose of the test procedures that was not discussed in detail there. Included in the set of interaction variables to be tested was the quadratic form of COMPT (COM_2). The secondary purpose for including this term was to attempt to discern some "optimal intensity of competition." COM_2 was selected only in the Forward Selection and the Stepwise results of the interaction tests for the CPPD model.[8] In the Forward Selection results, COMPT, COM_2, and two interaction terms, CM_LS and CM_PZ, were selected along with 14 other variables.[9] This model can be formulated as:

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[7]Ibid.

[8]See Table X, pp. 97-98.

[9]Ibid.

$$CPPD = 6.967\ (COMPT) - .528(CM\_LS) - .449(CM\_PZ) - .193(COM\_2) + (\text{the intercept term, the other 14 variables, and their coefficients}).$$

If the last term is assumed to be a constant, the derivative of CPPD with respect to COMPT is:

$$\frac{d\ (CPPD)}{d\ (COMPT)} = 6.967 - .528\ (LSTAY) - .449\ (PNLSIZ) - .386\ (COMPT).$$

Substituting their mean values (6.9 and 1.6) for LSTAY and PNLSIZ and combining terms, this can be rewritten:

$$\frac{d\ (CPPD)}{d\ (COMPT)} = 2.606 - .386\ (COMPT).$$

From an inspection of this derivative, we know that the second derivative will be negative for any value of COMPT and also know that CPPD will be at a maximum when the derivative equals zero. Setting the derivative equal to zero and solving for the maximum value of CPPD yields:

$$COMPT = \frac{2.606}{.386} = 6.751.$$

In the Stepwise results, COMPT and COM_2 were selected along with 7 other variables.[10] The coefficient of COMPT was 4.048 and the coefficient of COM_2 was -.341. The derivative of CPPD with respect to COMPT in this model is:

[10] Ibid.

$$\frac{d\ (CPPD)}{d\ (COMPT)} = 4.048 - .341\ (COMPT).$$

Setting the derivative equal to zero and solving for the maximum value of CPPD yields:

$$COMPT = \frac{4.048}{.341} = 11.871.$$

These results indicate that the "optimum intensity of competition" in Oklahoma hospital markets would be either "very few" or "very many" competitors. And since there are no hospital markets in the state with more than 10 competitors, it is likely that the optimum is "few" rather than "many."

The results of the factor analysis of the determinants of the average cost of hospital care gave considerable support to the theoretical soundness of the formulation of the average cost relationship. Additionally, the $R^2$'s resulting from the analyses imply that many of the models "found" by the stepwise techniques are useful in predicting the average cost of individual hospitals. The derivation of useful prediction equations is not the object of this study. Nevertheless, some further evaluation of the usefulness of these models in prediction is valuable. The useful model would be that which predicts accurately and precisely. In other words, that model where the confidence limits of its predictions were "compact" and the model's biases were not "excessive" would be a useful prediction model. It is discussed in Chapter IV that if regressors are excluded from a multiple regression model and the true values of their coefficients are not zero, bias is introduced. If, however, their true values are zero, the variance statistic of the least squares estimates is reduced.[11] The error mean square is an estimate of the variance of a model. In the Maximum $R^2$ results for the CPPD model, it was possible to observe the behavior of the error mean square (EMS) statistic. In the models where COMPT was selected, EMS fell from 50.596 in the 4 variable model to 34.108 in the 25 variable model. EMS then rose to 34.667 in the 30 variable model and to 43.751 in the "complete" 48 variable model. In the 25 independent variable model where EMS reaches a minimum value, the "width" of the confidence intervals for individual predictions also reaches a minimum. On this criterion, the 25 regressor model was selected as the "best" prediction equation. The results of the analysis of this model are compared with the results of the analysis of the 48 regressor model.

The S. A. S. Regression procedure has options that produce for each observation (1) the observed value of the dependent variable, (2) the value predicted by the model, (3) the residual, and (4) the upper and lower 95 percent confidence limits.[12] These limits are based on an

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[11]Rao, pp. 37-38.

[12]Service, pp. 94-98.

individual value of CPPD corresponding to the values of the regressors in each observation. In the "complete" 48 regressor model with an EMS of 43.751, a single observed value fell outside the 95 percent confidence limits. In the 25 regressor model where the EMS reached a minimum of 34.108, the same single observed value fell outside the 95 percent confidence limits. The $R^2$ statistic for the 48 regressor model is .89387 and .88445 for the 25 regressor model indicating less than a 1 percent loss in explanatory power by the elimination of 23 independent variables. These results indicate that there are useful models with fewer than 48 regressors that can predict the average cost of individual hospitals with a high degree of accuracy and precision. It is interesting to note that the multiple regression coefficient associated with COMPT is statistically significant at the 2 percent level in the 25 regressor model.[13]

The conclusions that are derived from the results of the analyses summarized here are that the formulation and specification of the model described by Equation (2) is theoretically sound and that it predicts average cost of individual hospitals satisfactorily; however, "restricted" models found by sequential model construction methods may be better predictors than the 48 regressor "unrestricted" models. The analyses of the 48 regressor models indicated that average cost curves were "U" shaped but that the output

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[13]See Table VI, p. 84.

variables indicating this characteristic were not relevant in explaining the variation in average cost. The degree or intensity of competition is an important determinant of average cost and the direction of its impact is in agreement with the study's hypothesis. The importance of COMPT is most apparent in the models found by the stepwise regression techniques where the number of regressors is restricted. The restricted models are better models in that the partial joint tests indicate that irrelevant regressors were eliminated.

## Implications of the Study

This study indicates that, in the state of Oklahoma, competition among hospitals for physicians is a cause of hospital cost inflation. This study has not discerned the precise responses of hospitals that increase their costs. Further research is needed concerning the relationship between the degree or intensity of competition and the particular responses of hospitals to attract physicians. No consideration has been given in this study to hospital policies regarding medical staff privileges or to hospital policies regarding the mechanisms through which medical staff express their wants. Such policies should be important considerations in further investigations. The scope of this study has been limited to a single state; any implications suggested here regarding other states or the nation as a whole require that the study's scope be expanded.

The analytical results of the study offer support for the assumption regarding the expected behavior of hospitals to respond to their physician-customers more intensely in competitive than in monopoly markets. If more substantial support is developed for the indication that economies accrue to high-capacity units, large regional hospitals or medical centers operating under, say, a "public utility" franchising arrangement would appear to be one solution to eliminate some of the inflationary pressures originating from physicians.

A more general solution would be to provide appropriate incentives for physicians to produce therapies using least-cost combinations of medical inputs. However, insured patients might not purchase least-cost therapies unless less costly alternative medical goods and services are as intensely insured as is hospital care. Therefore, some restructuring of health-care insurance would appear to be a prerequisite to the provision of such incentives. Health Maintenance Organizations (HMO's) have been suggested as a possible solution as they incorporate many of the above features. HMO subscribers generally have insurance-type coverages for most all medical goods and services rather than the usual hospital-only coverages. Physicians associated with HMO's are paid whether or not subscribers want or require medical care. There is usually an incentive for physicians to select least-cost combinations of medical inputs in producing therapies in that the "profits" of the

HMO and the physician are higher if, for instance, a subscriber is not admitted to a hospital when treatment as an outpatient is a satisfactory alternative. If the hospital is owned or controlled by the HMO, there will be cost savings in the production of hospital care associated with such efficient resource allocation. If, however, the hospital used by HMO physicians is independent of the HMO, it is unlikely that its expected response to other physicians will be much changed.

These implications suggest that a rather radical reformation of the medical care industry and the associated health care insurance industry may be required in order to reduce or even rationalize hospital cost inflation. The term "rationalize" is used in the sense of reducing the demand for and the subsequent inflation in the hospital industry and increasing the demand for less costly substitute medical goods and services. Any proposal for a "National Health Service" to provide either medical care or health care insurance for all citizens must avoid perverse incentives that exist in the present medical care industry. Otherwise, continued increases in the cost of hospital care will result.

The suggestions for further research and the implications of the study discussed here are not complete. The contrary signs of the multiple regression coefficients of, for instance, open-heart surgery facilities (OHS) and diagnostic radioisotope facilities (DRD) require further study. The delimitation of relevant markets for hospitals also requires additional work. The suggestive implications regarding the effects of the profit incentive on hospital costs may only be a result of the small sample that is restricted to a particular geographic area. Other readers will likely see the need for additional research and draw different implications from the study's results. Nevertheless, the empirical results and the implications are in substantial agreement with the central hypothesis.

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APPENDIX

# LISTING AND IDENTIFICATION OF VARIABLES AND THEIR ABBREVIATIONS

# LISTING AND IDENTIFICATION OF VARIABLES AND THEIR ABBREVIATIONS*

| Variable Names from Equation (2) | Abbreviations | Identification |
|---|---|---|
| C | TCOST | Annual total expenditures for a hospital. |
| - | PCOST | Annual personnel expenditures for a hospital. |
| - | PERNL | Average full-time equivalent employees in a hospital. |
| - | BEDS | Number of adult and pediatric beds in a hospital. |
| - | BASS | Number of bassinets in newborn nursery. |
| - | BIRTHS | Annual live births. |
| - | ADM | Annual admissions. |
| $Q_1$ | ADMD | Daily admissions (ADM/365). |
| $Q_2$ | CENSUS | Average daily patient census. |
| $(Q_1)^2$ | ADM_2 | - |
| $(Q_2)^2$ | CEN_2 | - |
| $C/Q_1$ | CPAD | Average cost; cost per admission (TCOST/ADMD). |
| $C/Q_2$ | CPPD | Average cost; cost per day of patient care (TCOST/[CENSUS × 365]). |
| $E_1$ | ORATE | Occupancy rate (CENSUS/BEDS). |

*Each instance where characteristics of hospitals enter the model as zero-one (dummy) variables is indicated in the Identification column in this listing.

| Variable Names from Equation (2) | Abbreviations | Identification |
|---|---|---|
| $E_2$ | ADBED | Admissions per bed (ADM/BEDS). |
| $E_3$ | BBASS | Births per bassinet (BIRTHS/BASS). |
| $E_4$ | LSTAY | Length of stay. |
| $D_1$ | ACCR | Accreditation by either the American Hospital Association or by the American Osteopathic Association (one if accredited, zero if not). |
| $D_2$ | MEDSCH | Affiliation with an approved school of medicine (one if affiliated, zero if not). |
| $D_3$ | BCROSS | Approved for reimbursement by Blue Cross plans (one if approved, zero if not). |
| $D_4$ | MEDCRE | Approved for reimbursement by the Medicare program (one if approved, zero if not). |
| PM | PM | Hospital organized as a profit-making institution (one if for profit, zero if not). |
| L/K | PNLSIZ | Labor to capital ratio (PERNL/[BEDS + BASS]). |
| P | DWAGE | Wage rate; daily personnel expenditures per full-time equivalent employee (PCOST/[PERNL × 365]). |
| X | COMPT | Degree or intensity of competition; the number of competitors for each hospital. |

| Variable Names from Equation (2) | Abbreviations | Identification |
|---|---|---|
| $M_1$ | CANCER | Cancer program approved by the American College of Surgeons (one if hospital has program, service, or facility; zero if not). |
| $M_2$ | RESI | AMA approved residency training program (one, zero). |
| $M_3$ | INTERN | AMA approved internship program (one, zero). |
| $M_4$ | NURSE | Hospital-controlled professional school of nursing (one, zero). |
| $M_5$ | RECOV | Postoperative recovery room (one, zero). |
| $M_6$ | ICU | Intensive care unit (one, zero). |
| $M_7$ | ICCU | Intensive cardiac care unit (one, zero). |
| $M_8$ | OHS | Open-heart surgery facility (one, zero). |
| $M_9$ | FTP | Pharmacy with a full-time pharmacist (one, zero). |
| $M_{10}$ | PTP | Pharmacy with a part-time pharmacist (one, zero). |
| $M_{11}$ | XRT | X-ray therapy facility (one zero). |
| $M_{12}$ | CBT | Cobalt therapy facility (one, zero). |
| $M_{13}$ | RDT | Radium therapy facility (one, zero). |
| $M_{14}$ | DRD | Diagnostic radioisotope facility (one, zero). |
| $M_{15}$ | TRD | Therapeutic radioisotope facility (one, zero). |

| Variable Names from Equation (2) | Abbreviations | Identification |
|---|---|---|
| $M_{16}$ | PATH | Histopathology laboratory (one, zero). |
| $M_{17}$ | BLBB | Blood bank (one, zero). |
| $M_{18}$ | ECEP | Electroencephalography service (one, zero). |
| $M_{19}$ | IHTH | Inhalation therapy department (one, zero). |
| $M_{20}$ | PREM | Premature newborn nursery (one, zero). |
| $M_{21}$ | EXCU | Extended care unit attached to hospital (one, zero). |
| $M_{22}$ | SCU | Self-care unit (one, zero). |
| $M_{23}$ | RENI | Inpatient renal dialysis (one, zero). |
| $M_{24}$ | RENO | Outpatient renal dialysis (one, zero). |
| $M_{25}$ | PHTH | Physical therapy department (one, zero). |
| $M_{26}$ | OCTH | Occupational therapy department (one, zero). |
| $M_{27}$ | REHO | Outpatient rehabilitation unit (one, zero). |
| $M_{28}$ | PSYI | Inpatient psychiatric Services (one, zero). |
| $M_{29}$ | PSYE | Emergency psychiatric services (one, zero). |
| $M_{30}$ | OPD | Organized outpatient department (one, zero). |
| $M_{31}$ | EMR | Emergency department (one, zero). |
| $M_{32}$ | SWD | Social work department (one, zero). |

| Variable Names from Equation (2) | Abbreviations | Identification |
| --- | --- | --- |
| $M_{33}$ | HAX | Hospital auxiliary (one, zero). |
| $M_{34}$ | VLS | Volunteer services department (one, zero). |

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