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THE ECONOMICS OF MULTIHOSPITAL ORGANIZATIONS AND THE EFFICIENCY OF RURAL HOSPITALS

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CHAPTER I

INTRODUCTION

Statement of the Problem

Currently receiving attention at the local, state and national levels of government is the problematical future of rural hospitals. Health services provided in rural areas are claimed to be inferior in quality and more costly than in metropolitan areas. Furthermore, it is charged that the lack of physicians and other health professionals in rural communities restricts the supply of services. Increases in the average age distribution of the rural population increase the demand for specialized services frequently unavailable in the rural community. Improved technology in the health industry has contributed to improved quality of services, but at the same time has increased substantially the costs of purchasing and maintaining sophisticated equipment and facilities.

The major economic problem of the rural hospital appears to be a problem of scale. Relatively lower per capita incomes of the local community and low population density in service areas limit the effective demand for hospital services and thereby the size of hospitals. Indivisibilities of investment in human resources as well as in equipment and facilities required to deliver health care services at currently available quality levels suggest that hospitals with more than 50 or 100 beds enjoy economies of scale.

Empirical studies of hospital costs during the past ten years suggest that the optimum size of a community hospital lies between 200 and 400 beds.[1] However, the distribution of community hospitals by bed size in the United States and other countries is skewed towards hospitals of less than 200 beds. In 1973 more than one fourth of all United States community hospitals had fewer than 50 beds. Nearly three-fourths had fewer than 200 beds (Pettengill, 1973, p. 12), while one of every three beds in the United States was located in a nonmetropolitan area.[2]

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[1]For example, see Feldstein, M., 1967; Carr and Feldstein, P., 1967; Hefty, 1969; Francisco, 1970; Ingbar and Taylor, 1968; Berry and Carr, 1973; Berry, 1970; Keunne, 1972.

[2]The distinction between metro and nonmetro areas is arbitrary and depends on the specific definitions used. In the case cited above nonmetro areas refer to communities outside the Standard Metropolitan Statistical Areas (SMSA's). Metro areas are the SMSA's. Appendix A presents Oklahoma population data for commonly used definitions of metro versus nonmetro and urban versus rural areas.

"Rural" is also defined arbitrarily in terms of (1) a given population within a geographical area, (2) driving time, (3) the nature of geographic terrain, (4) the patient-physician ratio, (5) relative isolation, (6) life style, (7) community dynamics, and (8) demographic trends. (Phillips, 1972).

Proposed solutions to the deficiencies in the hospital industry include continuing the current trend toward increased size, drastically reducing the comprehensiveness of services available at each institution or reorganizing the components of the health care system. Of the three alternatives only the last offers promise of assistance to many of the smaller communities. Increasing size without effective demand would increase excess capacity and further strain the resources of the community. Further reduction of the scope of services currently offered by many small hospitals may be incompatible with the community's objectives of preserving the local hospital and of attracting physicians. The final proposal of altering the organizational structure of the independent hospital towards a multiinstitutional system has become more widely accepted in the past decade as a reasonable alternative within the hospital industry. (Astolfi and Matti, 1972)

A variety of multihospital forms have been recommended as possible alternatives to existing arrangements. Concepts such as regionalization of health care services, regional health centers or development areas and others have received wide attention in the health industry since the early 1900's. In countries where the health industry is centralized under government control, regional multihospital approaches have, indeed, taken visible forms, although in the United States these approaches have been the exception. Nevertheless, the number of cooperative efforts in the United

States by hospitals of all types has increased in the past ten years to a point where sharing may soon be the rule. For example, during the last three years five regional hospital nonprofit corporations have been organized in the state of Oklahoma.

The economic viability of the multihospital approach remains almost completely undocumented because of the paucity of evaluation research in this area. The limited number of hospital cost studies found in the literature have concentrated on the issues of hospital cost inflation, relative efficiency and optimum hospital size. A comprehensive review of the literature discovered only two significant studies of a multihospital system other than merger prior to 1975.[3]

Cooperative Arrangements and Economic Theory

The theoretical and empirical basis underlying multihospital arrangements is well known from similar organizational forms in other industries such as farm cooperatives, independent food chains and franchised distributors of various goods and services. Integration of autonomous entities

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[3]Multihospital Systems, An Evaluation (Cooney, 1975) is a longitudinal study of the Samaritan Health Service, Inc. and its activities between 1968 and 1972 as a multihospital approach to resolve a number of Arizona's hospital delivery problems. The first two of a 4 volume report conducted by the Health Services Research Center of the Hospital Research and Education Trust and Northwestern University were published in 1975.

An earlier evaluation of an unsuccessful development of a multihospital system is reported by McNerney and Riedel, 1962.

sharing common goals is observed in private industry across a broad spectrum of different organizational structures ranging ultimately to complete institutional merger.

The economic case for cooperative arrangements rests on the existence of potential external economies of scale in the production of functions or processes within the firm. The firm achieves economies of scale by delegating production of certain functions and processes to the cooperative which is then able to internalize existing technological economies or other external benefits of larger scale production. Thus, firms obtain cost reductions from reorganization of functions within the industry rather than from expansion in the scale of the firm. There are several reasons which indicate that potential external economies may be realized by hospitals through cooperative arrangements.

The scope of services produced by a hospital suggests the possibility that some or many of the functions combined within a given hospital size are of a nonoptimum scale. For example a 50 bed hospital provides many of the same functional services provided by a 200 or 700 bed hospital. Housekeeping, laundry, materials purchasing and handling, printing, medical records, transcription and maintenance, and other administrative and overhead services are all inputs into the hospital production function regardless of size. Examples of these functions are often found as specialized commercial businesses serving many clients.

Indeed, hospitals frequently contract for laundry and dietary services from commercial vendors when available.

The more specialized inputs such as pharmacy and laboratory services are examples of activities provided by small hospitals at less than optimum scales. Full time pharmacists are seldom found in hospitals with fewer than 50 beds. Neither are professionals such as pathologists and radiologists but they are usually available to the smaller institutions during visits by "circuit riders" serving several hospitals within a larger geographic community.

The indivisibility of high cost labor inputs is also found in the administrative support functions. For example, the small quantity of supplies purchased by the smaller institutions may not justify the specialization of the purchasing function possible with larger volume operations, although the number of different line items used by the small hospital will not differ significantly from that of the larger institution. Problems of handling and distributing more than 2,000 line item drugs, for example, are similar in all sizes of hospitals. Inventory control, storage space and certainty of timely delivery may be more costly for the smaller outlying hospitals than for the larger hospital located closer to regional distribution centers.

Additional advantages in terms of quality and cost containment may arise from hospital ownership of the service company. Cost containment benefits are expected from the improved buyer position of the hospital cooperative resulting primarily from discounts for quantity purchase, central billing and warehousing, and legal protection afforded nonprofit organizations. Quality improvement may arise from the ability to improve product specifications or to provide services or products not otherwise available.

The Hospital Shared Services Corporation

Medical Products Systems, Inc. (MPSI) was incorporated as a 501 (e) nonprofit tax exempt, hospital owned service corporation in December 1972 by seven rural institutions. Membership which is open to all nonprofit institutions grew from the original seven to 30 hospitals as of July 1975. Corporate by-laws state the organizational purposes:

> To perform on a centralized basis one or more of the following services: data processing, operating systems, purchasing, warehousing, billing and collection, food, pharmaceuticals, medical and general supplies, industrial engineering, laboratory, printing, communications, record center, personnel, leasing, and other shared services authorized by law.

The number of hospitals participating in the major service categories and value of group sales since December 1972 are shown in Appendix B as of July 1975. The degree of participation by member hospitals, however, varies considerably. For example, hospital drug purchases from the group as a percent of total hospital drug costs varies from 100 percent to nearly zero. Member institutions are free to choose to participate or not to participate in any of the services offered; however, some peer pressure to purchase from the group prevails. This option explains the wide variation of participation by member hospitals.

Incentives for group participation derive from the nominal investment fee at time of membership of $10 per bed and, most importantly, from the cost and quality advantages of the services perceived by the member institutions. Operating funds are generated by fee-for-service charges and mark-ups above cost in purchasing programs.

Objectives of the Study

The objectives of this study are:

a. to estimate the degree of returns to scale of producing the three hospital services of pharmacy, dietary and medical records and of total hospital operations including all hospital services.

b. to describe how participation in a shared services hospital cooperative affects the costs of hospital services.

c. to estimate the degree to which cooperative activities affect the costs of hospital products and services.

Total cost functions derived as reduced form equations from a Cobb-Douglass production function are estimated for a sample of 25 hospitals reporting primary cost and output data for the three hospital services for the three years 1972 through 1974. In addition, total cost functions are estimated for total hospital operations for the sample of

25 hospitals and for a larger sample of 68 hospitals for which data were available. Cost functions are estimated from cross sectional data for each year and for pooled samples of cross section-time series observations.

The effect of membership in cooperative arrangements is evaluated by comparison of estimated cost functions in the pharmacy service for member and nonmember hospitals and by comparison of estimated cost levels before and after membership in the cooperative. Data are annual observations between 1972 and 1974 on 68 acute care general hospitals located within the trade area of the hospital shared services cooperative, Medical Products Systems, Inc.

Differences in extent or duration of participation in the cooperative, in geographic location, in type of ownership of a hospital and in physician availability are accounted for in the specification of the estimated equations. To overcome the inherent difficulties of defining a homogeneous measure of hospital output the hospital sample was stratified according to scale of production measured by output proxies and scope and complexity of services. Average cost functions are also estimated for comparison of results reported in the literature of alternative functional forms employed by others.

Relevance of the Study

This study is similar to other research in recent years which has attempted to shed light on the nature of the production and cost functions of hospitals. The common purposes of these studies have been to provide a framework within which the efficiency of the hospital operation can be assessed and to present empirical information about the actual performance of these institutions. The results of investigation into the cost-size relationship are as yet only tentative with evidence for both increasing and decreasing returns to scale in hospitals. In part, conflicting results are explained by the variety of different methods employed in the various research, and perhaps, more importantly, by the concentration on aggregate costs of production, for which data is more readily available. Studies of disaggregated services and functions are less frequent, chiefly because of the limited data reported by hospitals at a disaggregated level.[4] Furthermore, the general specification of hospital cost functions has characteristically omitted input prices from estimated equations.[5] In addition, the

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[4]Hospital cost studies which have considered disaggregated cost categories either by department or function include, for example, Feldstein, M., 1967; Fox, 1973; Feldstein, P., 1961; Cohen, 1970; Keunne, 1972.

[5]Studies which have included estimates of factor prices in cost functions include, for example, adjustments for wage differences, Feldstein, P., 1961; Cohen, 1967; and for capital costs, Feldstein, 1967; or both Berry, 1973 and an explicit explanatory variable for average wage rate, Fox, 1973.

majority of cost studies have been restricted in their analysis to data for years prior to 1970.[6]

As a study of hospital costs, this thesis uses disaggregated data for three services or departments in addition to aggregate data for total hospital expenses. It also offers the advantages of including factor prices in the specification of estimating equations. Furthermore, estimating equations are derived from a production function of known properties rather than from an unspecified production function. Finally, the data used are post 1970.

In addition, this study explicitly considers the influence of spatial factors on production costs. Studies of spatial location of industries suggest that a relatively wide distribution of separate institutions is related to population density and distribution patterns in service oriented industries. Failure to include spatial factors in the analysis of cost-size relationships of geographically remote hospitals in sparsely populated regions would tend to overstate estimated costs of production at smaller scales.

Furthermore, the topic of this thesis is a central issue of public policy currently receiving attention at the local, state and national levels of government. For example, demand for the local hospital regardless of size may reflect

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[6]The more recent studies published have treated data from previous years. For example, Ingbar and Taylor, 1968, used data from 1958-59 and 1963. Berry, 1970 and 1973, used data from 1965-67; Baker, 1973, used 1970 data; Keunne, 1972, used 1964-70 data.

the importance of the hospital to the local community. From the community's perspective the hospital is often a public service as essential to the vitality of the community as the local school system. The economic survival and development of the community may be critically affected by the presence of a hospital, which in many cases is the largest single employer, and thought necessary to attract or retain industry and labor in the area. Furthermore, recent shifts towards Medicare, Medicaid and other third parties as sources of hospital revenues may offset some costs to the community of supporting its hospital. Finally, community attitudes are clearly reflected within state and local government priorities which have stressed the objective of providing improved health care delivery systems to the underserved and rural regions of the country.[7] While public policy is clearly concerned with the trade off between efficiency and other socially desired objectives, such as health care accessibility, there remains to date inadequate knowledge of the nature of these trade offs or of alternatives for their improvement. Finally, this thesis is a case study of the effectiveness of a multihospital cooperative as an alternative to the operation of selected hospital services as individual entities.

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[7]Recommendations related to multihospital systems and rural and underserved areas included among ten national health priorities of the Health Resources Planning and Development Act of 1974, Public Law 93-641, Section 1502, are shown in Appendix C.

Organization of Study

Chapter II presents the economic theory of cooperative arrangements. Chapter III reviews the literature pertaining to empirical studies of economies of scale in hospital production of aggregate output and of output of individual hospital departments and services. Chapter IV describes institutional aspects of the hospital industry which are relevant to the development of multihospital organizations and the emergence of the hospital cooperative, M.P.S.I., which serves as the empirical basis for this thesis. The empirical model, estimated equations and results are presented in Chapter V. Conclusions and recommendations for further research conclude the study in Chapter VI.

CHAPTER II

THE ECONOMICS OF COOPERATIVES

A cooperative exists when two or more separate firms jointly provide a common service, function or process. The organizational arrangements among the firms will range across a multitude of dimensions one or more of which will vary along a continuum from total independence to complete merger. (Starkweather, 1970)

The economic argument in support of cooperative arrangements is that unit costs of production will be lowered. It is claimed, for example, that lower unit costs may result from reduction in capital outlays, by elimination of duplicated facilities, and improvement in the ability to conduct research and long range planning. Furthermore, cost reductions may enable extensions to be made in the scope of goods and services produced as well as improvement of the quality. (Edwards, 1972, p. 25) In other words, the successful cooperative may provide a relatively more cost efficient mode of production compared to the autonomous firm.

A firm may be inefficient in three ways. Technical inefficiency refers to a firm's use of suboptimal technical knowledge in the production process such that available techniques could produce a greater output with the same amount of factor inputs. Price inefficiency refers to the nonoptimum combination of factor inputs such that a given output could be produced at a lower average cost by utilizing factor inputs in different proportions. Finally, scale inefficiency is said to exist if a reorganization and new division of output among firms could achieve lower industry costs.

In long run equilibrium analysis of competitive industries, firms are efficient in all three senses. Growth of the industry, however, disturbs the equilibrium and defines new short run cost and output conditions. Following growth in market demand, the efficient firm will respond to new market conditions of demand which may result in a different scale of production or a different organizational structure. Firms not responding to new market conditions will be price inefficient if expansion in the industry altered relative factor prices and will be technologically inefficient if industry expansion led to technological improvements. However, a firm operating efficiently in the short run may be scale inefficient if it is not operating on the industry long run average cost curve. In such a case, altering the scale or organization of output will enable the firm to produce at lower average costs.

In the strictest partial equilibrium analysis of a competitive industry, unexploited economies internal to from expansion of the industry to a size large enough to support trade publications and other information exchange media.

The third and most relevant external economy with respect to cooperative arrangements is the "vertical disintegration" which may accompany an expanded market as industry output is reorganized and divided among firms.[1] The primary economic argument for cooperative arrangements is a special case of this third example in which decreasing cost functions and processes are delegated to auxiliary industries which are able to obtain economies from larger scale production.

Stigler succinctly describes the case.

> The number of processes to which a raw material is subjected in its transformation into a finished consumer commodity is indeterminably large. We may, for example, distinguish the making of flour and the baking of bread, or we may distinguish the greasing of pans, the kneading of dough, or the lighting of ovens. The question arises: how are those functions divided up among firms? What determines whether retailing will be undertaken by manufacturers, or ore mining by steel companies, or credit extension by doctors?
>
> When a product is produced on a small scale, the firms must produce their own specialized machines, marketing, research, training of labor, construction of plants, etc. (Stigler, 1952, p. 145)

Which process will likely be separated from the parent firm and produced independently depends for the most part on

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[1]There is some question if vertical disintegration is a valid example of an externality. Blaug accepts the example originally presented by Marshall but cautions that it may not be fully reversible as required by partial equilibrium analysis. (Blaug, 1968, p. 388)

the degree of returns to scale in the various processes and the size of the industry. The most likely candidates for separation and specialization are those processes exhibiting decreasing long-run costs as industry output expands, i.e., increasing returns to scale.

> As the industry's output grows, the firms will seek to delegate decreasing and increasing cost functions to independent (auxiliary) industries. For example, when one component is made on a small scale it may be unprofitable to employ specialized machines and labor; when the industry grows, the individual firm will specialize in its production on a large scale. (Ibid., pp. 145-146)

To illustrate more clearly assume that a hospital (firm) is providing the consumer product cotton balls to the patient within the hospital.[2] This activity may include processes such as (1) receiving sterile cotton in bulk form, (2) processing the cotton by reducing the bulk into individual cotton balls, and (3) distributing cotton balls to patient locations. Assume that process (1) is a constant cost function such that the average unit cost, C_1 shown in Figure 1, does not vary as quantity of cotton received increases. However, reducing bulk into cotton balls, process (2) may be assumed to exhibit decreasing costs as the volume of cotton balls increases, perhaps because of the introduction of specialized cotton ball making equipment. Thus, the average cost curve for process (2) shown as C_2 is declining as quantity increases. Process (3), cotton ball distribution, is assumed to be cost increasing

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[2]This example is adapted from Stigler, 1952, p. 146.

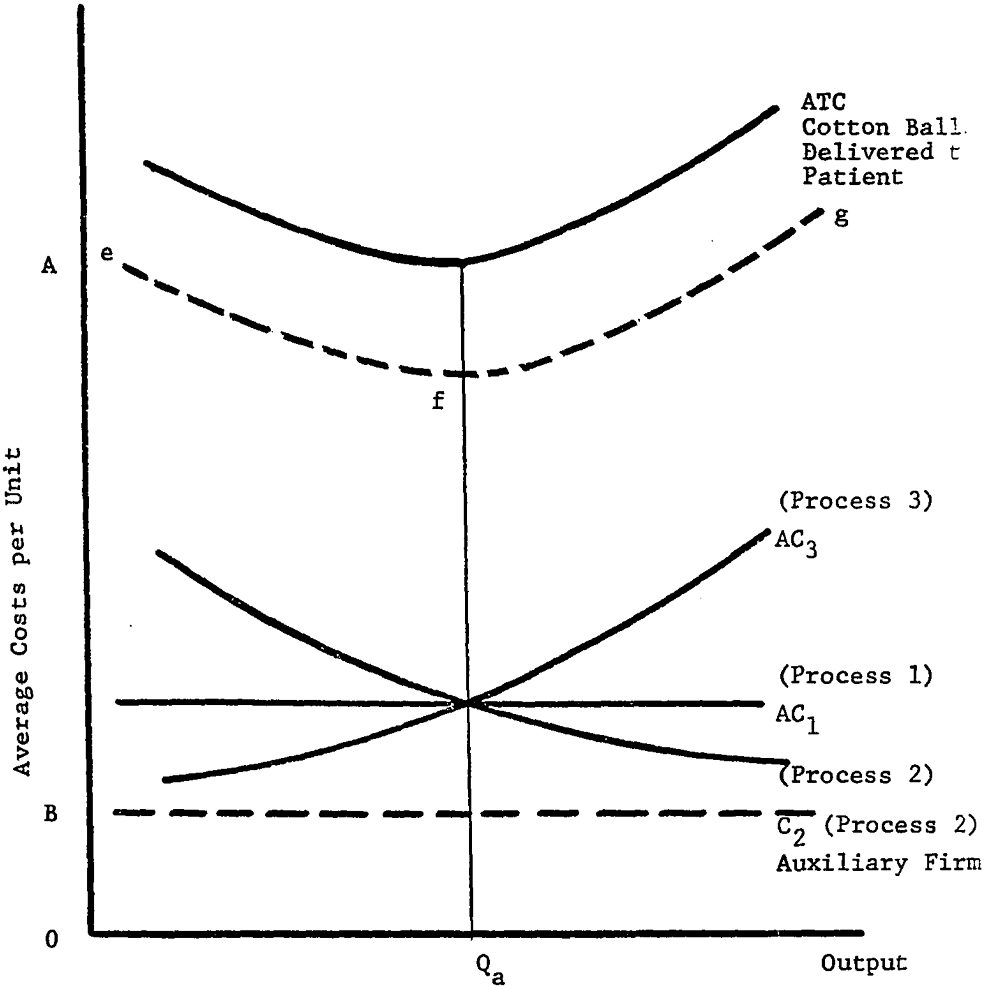

Figure 1. Average Costs of Production: Cotton Balls Delivered to Patient, by Processes 1, 2 and 3.

with an increase in quantity delivered, perhaps because of managerial difficulties in control as distribution scale expands. Average total cost, the sum of the three average cost curves, is shown as the ATC curve in Figure 1.

When the hospital provides all three processes at a scale shown as Q_a, the average cost of production is shown as OA on the vertical axis. With the entrance, however, of a specialized firm providing process (2) to the hospital at price OB, the new average total cost curve becomes that shown by the dashed line segment efg. In this situation the hospital would achieve the lowest unit cost at point f on the dashed segment of the ATC line by purchasing cotton balls directly from the auxiliary firm, and then performing the receiving and distributing processes. From the firm's perspective lower unit costs for process (2) available from the auxiliary firm offer the incentive to delegate production to the specialized firm. In this manner potential economies of larger scale production which were unavailable to the firm at its smaller scale are realized. The auxiliary firm may experience lower costs by internalizing existing technological efficiencies such as greater specialization in production or by realizing other external economies associated with its larger scale such as, the "labor force" case and the "trade journal" case.

From the parent firm's perspective, each of the many functions and processes may be considered an intermediate product which enter at various stages into the production of final consumer goods and services. The emergence of the auxiliary industry specializing in a declining cost intermediate product causes the industry's long run average cost curve to shift downward. Figure 2 shows the long run average cost curve of a typical firm in the parent industry as $LRAC_1$. Scale efficient firms operating along $LRAC_1$ acquire the intermediate product from an auxiliary industry while scale inefficient firms not utilizing the auxiliary industry are shown at higher cost levels operating for example along the line segment AB. A firm producing output Q_a would lower its average cost of production from C to D by delegating production of the intermediate product to the auxiliary industry. A firm producing output Q_b, however, would experience an average cost of B whether production of the intermediate product was performed by the firm or delegated to the auxiliary industry. The scale Q_b, at which further economies from larger production internal to the firm are equal to those obtained by the auxiliary industry, depends on the nature of returns to scale in production of the intermediate product.

The magnitude of the cost reduction brought about by the entrance of the auxiliary firm depends on the degree of returns to scale actually experienced. Cost reductions would increase as long as the auxiliary firm was able to expand scale within the range of declining costs. Thus, further expansion in demand for the intermediate product

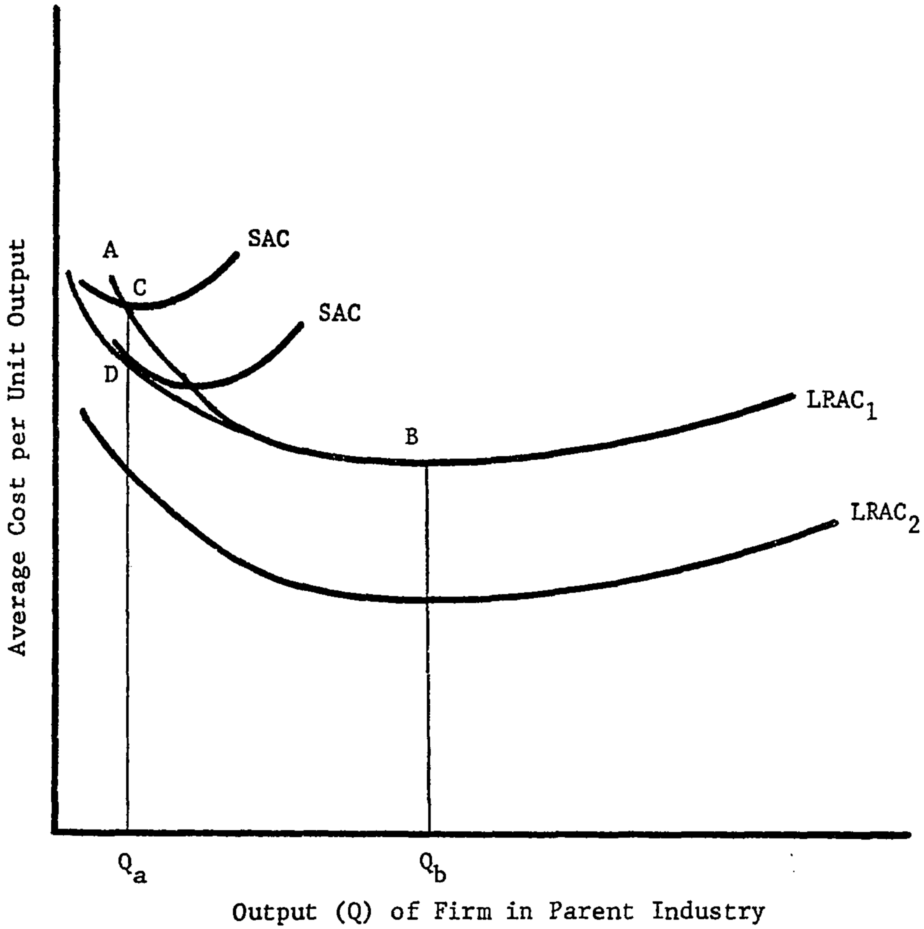

Figure 2. Long Run and Short Run Average Cost Curves of Firms in Industry.

accompanied by increased scale of the auxiliary firm would bring about further cost reductions and subsequent downward shifts in the $LRAC_1$- curve within the range of declining costs.

Furthermore, smaller scale firms may achieve a relatively larger cost reduction than larger firms whose scale already obtains some or all of the economies realized by the auxiliary firm. Similarly, firms serving limited markets in rural areas may experience relatively larger cost reductions compared to urban firms located in larger markets.[3] For example, consider firm A producing output Q_a which is smaller than firm B producing output Q_b. As independent firms, the respective average costs of production are shown at points C and B. Acquisition of the intermediate product from the auxiliary firm reduces firm A's average cost to D on $LRAC_1$. However, should firm B employ the auxiliary firm, its costs would not change from B. As the cost curve flattens, the gain in relative efficiency declines since the larger firms are already of sufficient scale to internalize some of the economies achieved by the auxiliary firm.

It may also be argued that there exist potential general external benefits associated with the auxiliary industry. Such externalities would benefit all firms in

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[3]The rural-urban argument rests on the existence of separate markets circumscribed by travel time and distance for firms in the same industry. Reorganization of firms operating in two or more such markets through a cooperative arrangement may serve to partially integrate what were previously independent markets.

the parent industry independent of how the firm chooses to acquire the intermediate product. The effect which is to shift the long run average cost curve from $LRAC_1$ downward to $LRAC_2$ as shown in Figure 2, does not depend on the assumption of declining costs in production of the intermediate product although the net benefits from the general externality must be positive.

Multiproduct Output

The discussion has implicitly assumed a single homogeneous product is produced by the industry, but the production process may include multiple final products resulting from many intermediate processes and functions occurring at various stages of production. If X and Y are joint products such that they are produced in fixed proportions, the theory of a single product firm is applicable. (Ibid., p. 129) The costs of production of one cannot be separated from the costs of producing the other and must be considered together. The analysis of economies of scale is the same for one as for both products.

Alternatively, multiple products of a firm may be considered independent products in the sense that variations in the production of one product have little or no effect on the marginal costs of another product. In such cases, multiproducts need not cause difficulty in analysis since marginal cost curves can be determined for each product separately. (Ibid., p. 130)

Stigler suggests that an explanation of why a firm would produce both X and Y together lies ". . . in the desires of buyers or in the diversification of output to achieve a steadier rate of aggregate output." (Ibid.) On the one hand convenience to buyers may explain, for example, why a firm would employ common functions in the distribution of a broad range of goods and services. In this regard, the products may be characterized as independent products at one stage of production and joint products during other stages of production. Products X and Y for example may be complementary inputs at a final stage of distribution at which time X and Y become a joint product when delivered to the consumer. Furthermore, fluctuations in aggregate demand for the firm's output may be dampened somewhat by providing a diversified range of products. In this case, economies of scale are realized in the use of one or more factor inputs common to production of two or more independent products.

The firm would tend to increase its aggregate size by adding to its product mix as long as economies of scale from the expanded use of common factors were sufficient to cover additional costs of the new product. The range of product mix would be limited by such factors as the extent of the market for individual products, the contribution to total product costs of the common factors, and by the magnitude of returns to scale in use of the common factor.

For example, consider the production of two final products, X and Y, employing specialized factors E and F respectively and the common factor Z such that

$$Y = f(E,Z) \text{ and } X = f(F,Z).$$

Factors E and F may be, for example, the labor services of specially trained technicians or specialized equipment peculiar to the respective products, while the common factor Z may be a service, process or function such as administration, distribution, or purchasing. The decision to produce X and Y within the same firm hinges on the existence of economies of scale in the utilization of the common factor Z. Such economies result from the indivisibility of factor Z. Lower unit costs of X and Y are achieved by spreading fixed expenses associated with factor Z across the larger total output of X and Y together.

Cooperative Arrangements or Autonomous Firms

The auxiliary industry may include autonomous firms as well as arrangements by which firms in the parent industry preserve some degree of organizational control over auxiliary firms. As an example of the latter case, the cooperative represents less than complete vertical disintegration by firms in the parent industry and a partial horizontal integration among firms. Economic reasons which may explain the preference for the cooperative organizational form include barriers to entry of auxiliary firms, sources of increased demand for the auxiliary firm's product and special incentives such as tax differentials or subsidies.

Barriers to entry of new firms are usually related to market imperfections, imperfect information, or indivisibilities of investment. For example, limited knowledge, uncertainty of the technical feasibility of new production methods or large minimum investment requirements may make financing of the auxiliary firm more costly from sources outside the parent industry. However, the cooperative arrangement may reduce risks by providing greater assurance of market demand. Firms in the parent industry may also find the cooperative to be a means of obtaining greater control over sources of supply. In addition, a cooperative may enjoy a favorable competitive position because of a nonprofit tax exempt status, or it may develop as a means of improving the market position of the member firms facing imperfectly competitive suppliers. Examples are obtaining bulk quantity discounts and improved ability to control product specifications and quality.

The auxiliary industry may result in response to increased demand for its product derived from expansion of a single parent industry or from expansion in several industries employing the intermediate product. It would be expected that the cooperative more likely would be the preferred organizational arrangement of the auxiliary firm if it specialized in producing a product unique to a single parent industry.

Summary

The economic basis for the multihospital organization rests upon the existence of substantial economies of scale in the production of numerous functions, activities or elements which are independent products at a particular stage of production. Because markets are too limited for rural hospitals to achieve potential scale economies, cooperative arrangements may be more economically feasible for these smaller hospitals than for larger ones.

Investigation of how changes in hospital organization may alter costs in the long run can be approached by estimating returns to scale in production of individual functions, departments and services by autonomous hospitals. In cases where cooperatives are operational, the economic effect of reorganization of hospital production can be examined directly by comparing hospital production costs of intermediate products before and after reorganization occurred and by comparing the relative cost efficiency of providing hospital services under the autonomous and cooperative organizational structures.

CHAPTER III

REVIEW OF EMPIRICAL LITERATURE

Chapter II presented the theory of cooperative arrangements as a special case of the more general model in which potential economies of scale are achieved by the firm through delegation of declining cost functions and processes to an auxiliary industry. This chapter reviews the literature related to studies of economies of scale in hospitals, discusses the conceptual and empirical difficulties in choosing the proper measure of output, and summarizes the results of the various hospital cost studies with respect to the shape of the long run average cost curve, the presence, or absence, of economies of scale, and other variables explaining variations in hospital costs.

Studies of the variation among hospital costs usually take the following general functional form:

$$C = f(O, Q, M, P, L, E)$$

where C is average unit or total cost of output, O equals the level of output; Q represents quality of services; M represents scope and complexity of services or case mix; P is a vector of factor prices; L accounts for geographic differences in location; and E is relative technological efficiency. While theoretical agreement is perhaps possible with respect to the variables to be included in the specification of the cost function, there is neither theoretical nor empirical concensus on the appropriate measures for these variables.

In summarizing the availability and quality of data for the above variables, Berry (1970, p. 70) finds no available data which directly measure quality (Q) or efficiency (E). Data on factor prices (P) are also of limited usefulness because of the lack of accurate indices for the multitude of products, equipment and human resources entering the hospital production process. Measures such as average wage rate (Berry, 1970) and starting salary (Cohen, 1967) are examples of proxies for factor prices. While cost data are readily available for some aggregate measures of output such as total hospital expenses, cost per patient day or per admission, these measures are crude approximations of the costs of the multiproduct output of hospitals. More difficult to acquire are cost data for disaggregated measures of output such as for wards, departments or disease categories.

Because of the conceptual problems of defining what the hospital industry produces and because of the restrictions imposed on researchers by data limitations, the available literature pertaining to hospital costs reflects a variety of approaches and different methodologies.

Review of the various studies reported in the literature yields a complex array of tentative results from what is yet exploratory research. Perhaps the most distressing difficulty present among all hospital cost studies is the inadequacy of definitions of what the hospital does produce.

What the Hospital Produces

Berki identifies six approaches to defining hospital output.

(1) Patient Days, weighted or unweighted

(2) Hospital Services

(3) Episode of Illness

(4) End-results and Health Levels

(5) Intermediate Inputs

(6) Composites of one or more of the above

Cost studies have confined their empirical work to output measures of patient days, hospital services, and composites of these two while generally ignoring (3), (4) and (5) above.

Studies have employed four approaches to adjust empirically for the multiproduct nature of hospital production. First, direct adjustments to measures of output include:

1. readily available measures such as the number of annual patient days or average daily census; the number of annual admissions, discharges, or cases which are assumed to be homogeneous;

2. adjusted patient days which incorporate a weighted measure of nonacute care services such as outpatient visits provided by the hospital;

3. weighted measures of output based on the proportion of costs per disease category to total hospital costs or based on allocated costs according to weights determined by time and motion studies.

Second, indirect adjustments to output which use one of the above measures plus the addition of other explanatory variables such as the inclusion of:

1. the number of services and facilities offered by the hospital;

2. dummy variables in multivariate analysis to indicate the presence or absence of facilities, services, teaching programs, and other qualitative attributes which might influence product mix;

3. a case mix index constructed by scaling of hospitals according to scope and complexity of services;

4. ratios to indicate the proportion of cases treated in different disease or service categories such as the proportion of total cases which were in obstetrics; the proportion of total hospital staff which were interns, residents, or nurses.

Third, hospitals have been classified into stratified samples according to:

1. the same size group measured by the number of beds, patient days or other proxies for size;

2. the identical number of services and facilities offered or the identical services and facilities offered;

3. ownership, such as federal, state or local government, voluntary nonprofit, and for profit.

Finally, disaggregation of the hospital into separate departments and services may enable selection of more homogeneous measures of output for each service. Both direct and indirect adjustments described above may further improve homogeneity of these output proxies.

Patient Days

The number of patient days per time period is the most frequently used measure of hospital output. Closely related is the number of admissions or discharges per period. The difficulty of using gross measures of hospital output such as these arises from the multiple dimensions across which costs and output may vary thereby rendering the output measure incomparable either within the same hospital over time or between hospitals.

Berki discusses three different types of distinct services associated with each patient stay: admission-specific, stay-specific and diagnosis specific.

> Admission-specific services, such as chest X-ray examination and blood test, are independent of the diagnosis on admission or discharge or of the length of stay. Stay-specific services, such as routine nursing care and hotel type services are determined by

> the length of stay, again largely independent of the nature of illness. Diagnosis-specific services, such as laboratory, inhalation therapy, ... surgical operation, ... and other specialized services are determined neither by act of admission nor by the length of stay but by the suspected or defined diagnosis, modified by case severity.
>
> Stay-specific services, nursing and hotel types, may be quite adequately captured by unweighted patient days. Admission-specific services, however, will not be adequately reflected unless patient turnover is explicitly considered. And to the extent that the ancillary, specialized, service intensity of care exhibits a degree of heterogeneity among and within diagnostic categories, ten days of patient care delivered in the same hospital during the same time interval to two different patients, one with cerebral hemorrhage and the other with a broken leg will correspond to different sets of services, with different capital and labor intensities. (Ibid., p. 34)

Hospital output and associated costs are clearly subject to variations along each of the possible dimensions of output. For example, analyses of time series data which use patient days as a measure of output suffer from additional biases, since the intensity of care and amount of ancillary services may have increased over time while the average stay for a given illness may have decreased.

Cohen (1967) objects to the use of patient days as a measure of hospital output because of ". . . a systematic bias against larger hospitals which may offer many more kinds of services."

> Many small hospitals, rather than offer a particular service at low volume and consequent high unit cost, will have an agreement with large hospitals in nearby cities to provide the service in question. Such arrangements may reflect insufficient demand in the vicinity of the smaller hospital for either specialized equipment such as cobalt units or specialist physicians such as neurosurgeons; but these arrangements foster an appearance of relative efficiency in the smaller hospitals. (p. 358)

To overcome these difficulties researchers have weighted or grouped services and facilities and alternatively have considered hospital output in relation to diagnostic treatment actually provided. No attempts are known to deal with the numerous dimensions of the patient demographics.

Weighted Output Measures

Two studies have attempted to standardize patient days. Seathoff and Kurtz (1962) propose a new measure called "units of service" derived from a weighted "output" from seven (7) hospital operating services. (p. 14) The authors admit to the arbitrariness of weights but suggest their measure is an improvement over patient days. Cohen (1967) suggests weighting the departmental contribution to total hospital output on the basis of relative departmental costs. He estimates separate average service costs, determines his weights by calculating average service cost as a proportion of the unit cost of adult and pediatric days, and then estimates weighted output by summing the products of the weights and the output quantity of each service. (p. 360)

Both approaches follow the same basic pattern: weighted patient day cost (S) is the sum of weighted costs of i services, such that

$$S = \sum_{i=1}^{n} W_i \cdot Q_i$$ where W_i is the weight for each factor,

Q_i is the quantity of output of each of the i services, and n is the total number of services. Whereas Cohen estimates

W_i by comparing the ith average service cost to the cost of inpatient pediatric and adult days, Saathoff and Kurtz arrive at W_i for seven hospital services on the basis of time and motion studies and other expert considerations.

Whereas the above approaches attempted to adjust for the limitations of the patient day measure directly by redefining output as the sum of weighted services (or departments) of the hospital, other approaches have preferred to introduce exogenous variables to indirectly account for (or hold constant) the dimensions of expected variation.

Hospital Services and Facilities Available

Several attempts to compensate for the heterogeneity of hospital output have assumed that either the number or the type of similar facilities and services provides at least a partial adjustment. The simplest approach is one method tried by Carr and Feldstein in a study which classified hospitals by number of services and facilities.

A simple scaling method was used by Carr and Feldstein in their 1967 study in which the number of facilities and services listed for each hospital in the American Hospital Association's Guide to Hospitals was used to approximate a determinant of long run cost which is associated with complex and specialized services and which is relatively constant regardless of size. The same variables multiplied by 365 days per year, was also included as a relatively constant per patient day component. The authors recognized the implicit assumptions that costs associated with each service are equal, that each service classification used is comparable among all hospitals, and that the degree of utilization of each service is constant among hospitals of different sizes. Berry (1967) and others have also grouped hospitals according to the number of facilities and services provided.

The addition of independent variables has been used to improve the homogeneity of hospital output measures. (Berry, 1970, 1973; Berry and Carr, 1973) Berry (1970) suggested that "product mix might be approximated by selection from such information as accreditation, program approvals, facilities and services available, outpatient visits, births, and long-term patient days . . . and from such information as the number of student nurses, interns, residents, and other trainees. . . ." (p. 71) Forty dummy variables, employed in regression analysis, accounted for 26 per cent of the total variation of cost per average daily census. Recognizing the presence of multicollinearity in his estimates, Berry factor analyzed the 40 variables used to represent product mix. Eight common factors were found which explained 60 percent of the variation among the 40 variables. While his approach is tentative and the details of his factor analysis were not presented, the results suggest the existence of eight identifiable dimensions of product mix which may account for variation among hospitals.

Berry suggests the identity of the eight dimensions: medical school or teaching; basic services; length of stay; complex services; outpatient activities; routine admissions; presence of nursing school; and training of practical nurses. (p. 74)

Berry and Carr (1973) present evidence to support their conclusion that

> The range of services provided in hospitals extends from the most basic services provided in a small institution with exceedingly limited facilities, through a somewhat higher quality of essentially basic services, through the more complex services, to the services provided in a hospital which serves as a community medical center in addition to its role as an inpatient institution.

Their conclusions are based on an analysis of the relationship between the number of facilities and services provided by hospitals to the specific services and facilities provided. A 30 by 30 element matrix was formed to compare the number of facilities and services (1 through 30) as rows to the specific facility or service in columns. "Thus, a given matrix element showed the number of i facility hospitals which had the jth facility. (For example, how many 10 facility hospitals have a blood bank?)." (p. 57)

Similarly, another matrix was formed by dividing each element in a row by the sum of the elements in that row to indicate the proportion of i facility hospitals which had the jth facility. From this analysis the authors concluded that facilities and services are added by hospitals in a systematic fashion which allows for the grouping of hospitals into five categories suggestive of their scope and complexity of care offered. The services included in each of the five categories are shown in Table 1.

The first category includes five services which seem to be basic services defining characteristics of the smaller hospitals.

> All five basic services are present in more than 50 percent of the hospitals by the time they have five facilities and they are present in more than 75 percent of the hospitals no later than when they have six facilities. The pattern prevails for all hospitals regardless of the type of ownership. (Ibid., p. 59)

In a sequential fashion, basic service hospitals will next add what the authors call "quality enhancing" services and facilities as shown in the second category. Quality enhancing services are characteristic of 10 to 12 facility institutions when present in 50 percent of all hospitals and 14 or 15 facilities when present in 75 percent of all hospitals. The mean bed size of the second group is 95.4 beds compared to a mean of 43.1 beds for the basic services group.

The third category describes hospitals which have added "complexity expanding" services which characterize institutions in the range of 15 to 25 facilities and with a mean bed size of 230.8 beds. These services are characteristic of inpatient care services for treatment of more complex diagnostic disease categories.

TABLE 1

FACILITIES AND SERVICES BY SERVICE TYPE

BASIC SERVICES

Clinical Laboratory
Emergency Room
Operating Room
Obstetrical Delivery Room
X-Ray, Diagnostic

QUALITY ENHANCING SERVICES

Blood Bank
Pathology Laboratory
Pharmacy with Pharmacist
Premature Nursery
Postoperative Recovery Room

COMPLEXITY EXPANDING SERVICES

Electroencephalography
Dental Facilities
Physical Therapy
Intensive Care Unit
X-Ray, Therapeutic
Radioisotope Therapy
Psychiatric Inpatient Unit
Cobalt Therapy
Radium Therapy

COMMUNITY SERVICES

Occupational Therapy
Outpatient Department
Home Care Program
Social Work Department
Rehabilitation Inpatient Unit
Family Planning Service

SPECIAL

Hospital Auxiliary
Chaplaincy
Chapel
Routine Chest X-Ray
Routine Blood Sugar on Admission

Source: Berry and Carr, 1973, Table 15, p. 62.

The fourth and fifth categories, however, indicate the expansion of hospital output from acute inpatient care to include "community" and "special" services, respectively.

Diagnostic Categories

More appealing empirical approaches to defining output have adjusted patient days, and admissions or discharges, by including a measure of the proportion of diagnostic categories treated within the hospital patient day. M. Feldstein (1967) utilizing British National Health Service departmental data from 177 large, nonteaching hospitals adjusted for case mix by using the proportion of cases in each of eight specialty groupings. Feldstein concluded that

> Any attempts to compare hospital cost for administrative or research purposes, or to establish relationships between costs and other characteristics (e.g., number of beds), should therefore generally take case-mix into account. But the proportion of total variation that remains unexplained is, in all cases, quite large. Thus, inter-hospital cost variations are not merely a reflection of case mix but indicate differences in hospital efficiency, management efficiency, and standards of service. (p. 103)

The use of facilities and services available is only a second best approximation to product mix and is a practice followed primarily because of inadequate case mix data. For example, duplication of Feldstein's study of the British hospital system is not possible in the U.S. because of unavailability of data. Berry and Carr, however, in another 1973 study utilizing data available for 57 New England hospitals, attempted to compare the explanatory power of the facilities and services available proxy for product mix with the alternative proxy, proportions of specific diagnostic categories treated, a measure of what the hospital had in fact produced. In separate equations, average cost per admission or per patient was regressed on average daily census and the product mix variable.

The authors concluded that in both cases ". . . capacity to provide services explains hospital costs much better than the actual services provided. . . ." However, their conclusions are tentative because of the low number of degrees of freedom (19 and 27, respectively), the size of standard errors are seldom less than their estimated coefficients and none is significant at the .05 level, and finally, multicollinearity is almost certainly present.

Baker (1973) attempted to define a homogeneous measure of hospital output by factor analyzing (using Q technique of principle component analysis) monthly cost and disease category data for one Los Angeles hospital for 16 months. Baker found two plausible solutions of 3 and 5 identifiable factors common to the data matrix of 28 revenue centers (inputs) and 33 disease categories (treatments). The disease codes loading highest on each of the three factors were grouped together and the hospital product mix was defined as the number of discharges in each disease grouping. The three groups were identified as obstetrics (1st factor), complicated but low risk diseases (2nd factor), and very complex and high risk diseases (third factor). The third factor had a fatality rate 20 times that of the 2nd factor. Product mix defined in this manner appeared stable over the 16 month period of the study and was reported to be relatively homogeneous with respect to resource inputs. The limited usefulness of this approach, however, is indicated by the data requirement of reconstructing the 17,500 patient charge profiles for the one hospital in question. The assumption that patient charges accurately reflect cost of services, not a widely accepted presumption, was based on the observation that the hospital was using the latest cost accounting and allocation methods which related costs and charges in a systematic form.

Disaggregation by Hospital Function or Department

Analysis of hospital costs by individual departments and services is one possible way around the problem of heterogeneous measures of output. Disaggregation of hospital costs according to department, service or function may reduce the empirical difficulties of treating the multiproduct hospital as a single product firm. Each department, or service is more likely to approximate a single product firm than the total hospital. For example, the dietary department may be considered specialized in the production of food preparation and distribution, the output of which can be approximated by the number of meals served.

Another weakness of aggregating total hospital cost is that economies of scale present in some services will be offset by diseconomies of scale in other services.

Furthermore, the disaggregated approach to hospital cost analysis eliminates some of the difficulties of standardizing the scope and complexity of output captured within the measure of costs. For example, the problem of comparing costs of small with large institutions which provide different product mixes is minimized. Costs associated with services such as emergency room care, outpatient clinics, and other community services characteristically provided by the larger but not the smaller hospitals do not enter as a problem.

Knowledge of the behavior of costs by specific services or functions could lead to more rational planning for construction of new facilities, renovation or closure of other facilities or services and other organizational arrangements. Results of studies at departmental levels are reviewed in the following section on economies of scale.

Economies of Scale in Hospitals

Hospital cost studies of economies of scale have focused attention on the three variables, cost, scale and product mix. The usual form of the regression equation is:

$$C = a + b_1 0 + b_2 0^2 + b_i M_i + \text{error term}$$

In the case where average costs are estimated, the presence of economies of scale would be indicated by an expected negative sign for b_1 indicating a negative average cost-scale relationship, a positive b_2 suggesting the U-shaped average cost curve where at some larger scale average cost begins to rise with an increase in scale. The expected signs for b_i coefficients of the product mix variable M_i depend on the proxy used. A single variable index for M is expected to have a positive sign since the index measure increases with the scope and complexity of services which are thought to be cost increasing.

In those cases where M is a vector of dummy variables for approvals, facilities and availability of facilities and services, collinearity is a problem; however, most authors using this technique have ignored the difficulty. Where M is the number of facilities and services provided, the presence of collinearity is also likely. Where adjustment for product mix is accomplished by grouping hospitals according to identical facilities and services or the same number of facilities and services, M is omitted, and the collinearity problem is reduced.

In the cases where product mix is approximated by measures of case mix such as the proportion of all cases treated in specific departments or diagnostic categories such as the proportion of patients treated in the same diagnostic category, multicollinearity may be less of a problem.

Finally, the output adjustment methods of deriving weighted patient days incorporates the product mix adjustment directly into the output measure and eliminates M from the estimating equation.

Review of the literature on economies of scale in hospitals is summarized in Table 2 which shows chronologically the investigator, his basic findings with respect to the presence of economies of scale, the degree of the estimated cost curve, type of adjustment for product mix, the dependent and scale variables used and the level of aggregation, sample size, date and source of data.

One of the earliest studies of the cost-size relationship by P. Feldstein in 1961 found no difference in patient day costs between large and small hospitals. Since no adjustment for product mix was made to account for the greater complexity and scope of services offered by larger hospitals, the author concluded that the long run average cost curve must be downward sloping exhibiting economies of scale throughout the entire range of sizes of the sample of 60 hospitals (48-453 beds). (pp. 63-64) Presumably, the scale variable was picking up the effects not only of differences in size but also any differences in product mix produced by larger hospitals.

Three studies of hospital cost variation published in 1967 using different output measures and different data concluded that economies of scale are present in the hospital industry with minimum points of the long run average cost curve in the range of 125 and 350 beds.

TABLE 2

THE EXISTENCE OF ECONOMIES OF SCALE: SUMMARY OF FINDINGS

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
P. Feldstein (1961)	Declining average cost:	One	None	Average cost per patient day	Total patient days	Total hospital (60 hospitals
	For some departments marginal cost below average cost	One	None	Average cost per unit output in each department	Varied by department	Departmental (1 hospital)
Berry (1967)	Declining average costs	One	Stratification into 40 groups with identical facilities	Average cost per patient day	Total patient days	Total hospitals (5,293) 1963 data
Carr and P. Feldstein (1967)	U-shaped curve: minimum cost at 190 average daily census	Two	7 measures: no. facilities and services; no. outpatient visits; nursing school; no. student nurses and no. interns and medical school affiliation	Average cost per patient days	Average daily census	Total hospital (3,147) 1963 data

TABLE 2--Continued.

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
	Economies of scale exist over wide range of sizes in each of the 5 service capability groups; upward trend in level of costs from group to larger group	Two	5 service capability groups by number of facilities and services: 0-9; 10-12; 13-16; 17-19; 19-28, with above six product mix measures.	Average cost per patient days	Average daily census	5 groups at total hospital level (490-693 hospitals per group) 1963 data
Cohen (1967)	U-shaped average cost curve; minimum cost at 290 beds. (Range of flat bottom 250-350)	Two	Weighted output measure (S^k) from 13 depts. costs	Total costs	S^k	Total hospitals (82 or less) 1962 and 1963/64 data New York City sample
	U-shaped average cost curve; minimum at 160-170 beds.	Two	S^k modified for six state sample	Total costs	S^k modified	Total hospital (unknown) 1965 data from 6 state sample

TABLE 2--Continued.

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
M. Feldstein (1967)	U-shaped curves: coefficients not significant. Min. at 310 beds rising to plateau at 600 beds, 10% above minimum	One and two	Case mix adjustment by 8 diagnostic categories; proportion of cases in each of 8 categories	Average cost per case and per patient week	Number of beds	Wards and total hospital (177) 1960-61 data from British Health Service data
	U-shaped curves; coefficient of smallest group significant	One and two	Proportion of cases in each of 9 categories; adjusted for size groups into 2, 3, & 4 size groups	Average ward cost per case and per patient week	Number of beds	Total hospital (smallest size 15 in 4 group sample)
	No economies found in nursing or labor components of ward costs Economies found in: 7 of 14 categories of hospital costs using		Proportion of cases in each of 9 categories	Average cost per case, per ward or per cost category	Number of beds adjusted for flow: number cases per bed per year	14 individual cost categories; i.e., nursing, medical, laundry, catering, drugs, direct, and indirect

TABLE 2--Continued.

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
	linear quadratic equations for average cost per case. Minimum size range: 83 to 548 beds. Scale economies found in 11 of 14 quadratic equations for average cost per case flow. Minimum size range: 366 to 905 beds.					
Ingbar and Taylor (1968)	Inverted U-shaped average cost curve. Maximum cost at 190 beds.	Two	Used variables loading heavy on factors, but not factor scores to adjust for product mix.	Cost per patient day and cost per bed	Beds	Total hospital and departmental (72 Mass. Hospital) 1958-59 data

TABLE 2--Continued.

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
	Sign of size variable correct, not significant. Without multicollinearity conclusions may have been different.		Excluded hospitals with academic, municipal and religious affiliations.			
	Unit costs vary chiefly due to differences in service output		150 variables grouped in 11 major factors (principal component analysis)			
Berry (1970) Inquiry	U-shaped curves for each control group: all government voluntary and for-profit. R^2=.25; .50; .26; .18 respectively. Presence of multicollinearity.	Two	40 variables to describe presence of approvals, facilities, services, average length of stay; proportion of outpatient and births; teaching and medical school affiliation.	Average cost per patient day	Average daily census	Total hospital (547-5,684 degrees of freedom) 1965 data

TABLE 2--Continued.

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
	Minimum points: 1,300; 1,314; 1,017; and 240 beds, respectively.		Stratified into 4 groups according to control: all hospitals, government, voluntary and for-profit.			
	Of 25 groups, 4 showed decreasing average cost; 16 constant average cost.	One and two	Grouped hospitals by same combination of services.	Total cost	Total patient days	Total hospitals (4,710 groups ranged from 31-150)
Francisco (1970)	U-shaped cost curves: 7 of 9 groups with average number beds of 135 or less showed decreasing costs over range. Of 8 groups with average beds of 185 or more, only 1 shows significantly decreasing average costs.	One and two	Grouped hospitals by same number of services, and in separate analysis used single variable unweighted index and dummy variables for each facility and service.	Total cost	Total patient days	1966 data (16 groups with group range of 28-474 hospitals each)

TABLE 2--Continued.

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
	Minimum average cost levels increase with average size and number facilities in group. Unweighted index of facilities and services (one variable) and dummy variables for each facility and service yield similar results to those above.					
Cohen (1970)	U-shaped curve for services; decreasing average costs for EEG, EKG, Diagnostic X-ray; lab, ambulance and ER.	One, two and three	Weighted output index S^k as in '67.	Total cost of service	S^k and patient days	Services and departments 1962 and 1965 data (46 New York hospital) average size 400 beds

TABLE 2--Continued.

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
	Quality dummy significant in most services. Minimum points on long run average cost curve depend on quality dummy; 540 to 790 beds.		Quality dummy included for accreditation, medical school affiliation.			
Lave and Lave (1970) American Economic Review (1970)	Scale economies, if they exist, are not very large. Little significant cost-size relationship. Emphasis on changes in cost, not levels of cost.	One	Simple adjustment; allow each hospital separate intercept value to capture product mix differences under assumption that product mix for each hospital constant over period of a few years. Includes teaching, and location variables.	Cost per patient day	Number of beds	Total hospital (74 Penn. hospitals, semi-annual data) Time series and cross section analysis 1961-1967 data

TABLE 2--Continued.

Investigator (date)	Findings	Degree of Estimated Curve	Adjustment for Product Mix	Dependent Variable	Scale Variable	Level of Aggregation (Sample Size) and Data
Drake (1972)	Inverted U-shaped average cost curve. Maximum cost at 362 beds. Surgical activity more important than others in explaining cost variation.	One and two	Number of specialized services; proportions of obstetrics, medical and surgery cases per 100 patient days.	Cost per unit output	Patient days, adjusted patient days and number of cases	Total hospital (68 Nebraska) 1967-69 data
Edwards, Miller and Schumacher (1972)	Small returns to scale within each index level (size group) and with respect to overall costs and staffing of RN's Dummies for population density, residency, nursing school not sign when index used.	Two	4 weighted indices of facilities and services.	Total costs	Patient day adjusted and squared. General index (GI) GI^2	Total hospital (5,439) 1969 data

Berry (1967), using 1963 AHA data for 5,293 hospitals and 28 reported services, classifies hospitals by identical facilities and services into 40 groups. The largest group contains 92 hospitals with the identical seven services while the smaller groups of ten hospitals each have between 8 and 22 identical services. For each group Berry regressed average cost per patient day on total annual patient days. Berry concluded that his ". . . data overwhelmingly support the conclusion that hospital services . . . are produced subject to economies of scale" based on the correct negative sign of the estimated regression coefficient for the scale variable in 36 of the 40 groups, although only seven had "t" scores above 2.0 and only six had 22 or more degrees of freedom. (The median number of degrees of freedom was 13 with a range from 8 to 90.)

Carr and Feldstein (1967) also using 1963 data from AHA for 3,147 hospitals estimate a U-shaped average cost curve with a minimum cost occurring at an average daily census of 190 patients.

Estimation of cost functions for each of five "service capability groups" defined according to the number of facilities and services yielded the conclusion that economies of scale exist over a wide range of sizes in each of the five groups with an observed upward trend in the level of costs from group to larger group.

Carr and Feldstein conclude that small hospitals should not provide high service capability and large hospitals should not provide low service capability. These recommendations derive from their findings that there are economies of scale for hospitals providing the same service capability. That is, there are economies of scale from specialization in the production of particular services. The small hospital is limited in total output, and thus must divide its total output among the services it plans for and does provide. Obviously, for a given aggregate scale, each service will produce smaller output as the number of services increases. Stated in a different way, Carr and Feldstein concluded that "apparently, the greater the capability of a hospital to provide a wide range of diversified services, the more rapidly average cost initially falls with increased size." (1967, p. 45)

In 1967 Martin Feldstein updated his earlier study of case mix adjustment of the British National Health Service data from 1961 from which he concluded that case mix adjustment explained a statistically significant portion of hospital cost variation (1965). Using both linear and quadratic forms to estimate average cost functions, where the number of beds serves as the measure of scale, the author concludes that "Both equations indicate that when allowance is made for differences in case mix the average cost per case is unaffected by hospital size." Further analysis by stratifying hospitals into size groups (with a minimum sample size of 15) support the conclusion: "There are neither substantial economies nor diseconomies of scale." (p. 67)

Recognizing the possible importance of differences in occupancy rates and lengths of stay, Feldstein attempts to separate the "pure scale effect" from the "case-flow effect." Including the case flow variable in both linear and quadratic forms, Feldstein concludes that

> . . . if the number of cases treated per bed per year (the "case flow"...) were the same for hospitals of all sizes, the cost per case would decrease with scale. Larger hospitals have lower flow rates and this case-flow affect increases cost per case in a way that balances the pure scale effect which, ceteris paribus, would cause larger hospitals to have lower costs per case. However, even if flow rates were the same the economies of scale would be small; the evidence indicates that cost per case would be only ten percent lower in 1,000 bed hospitals than in hospitals of 300 beds. (p. 74)

Analysis of the two components of case flow suggested that differences in lengths of stay rather than occupancy rates was the source of the case flow effect on variation in hospital costs. (pp. 78-79)

In 1968 Ingbar and Taylor published the results of a comprehensive study of 72 Massachusetts general hospitals for the periods of 1958-59 and 1962-63. Although their methodology followed the general approach of estimating average cost functions, their results indicated an inverted U-shaped curve best represented the cost-size relationship for their sample of hospitals. Total hospital and departmental costs were analyzed using cost per patient day and cost per bed as alternate dependent variables and number of beds available as the scale variable. Their sample excluded hospitals with academic, municipal or religious affiliations. The novel aspect of their methodology which also accounts for some of its limitations (Berki, op. cit., pp. 93-94) is the use of factor analysis to aid in the selection of independent variables and to determine the best levels of aggregation. Using more than 100 variables on 72 hospitals for pooled data from 1958 and 1959 (144 observations) the authors identify 11 factors: size-volume, utilization, length of stay, laboratory, radiology, surgical, maternity, pediatric, and ambulatory activities, private services, ward services, and unrelated items. According to the authors the value of the factor analysis is ". . . that there are as many as 11 factors." (p. 40) On this basis the authors apparently are able to identify the appropriate independent variable ". . . that may affect costs" (p. 40) as the variable with the highest factor loading. No attempt to substitute factor scores of the eleven factors for independent variables is suggested nor are a priori hypotheses presented.

A factor analysis of departmental expenses using the same approach as described above discovered three distinct cost categories (three factors):

> The first category is a group of five departments--(1) laboratory, (2) radiology, (3) operating room, (4) nursing service, and (5) administration and general--whose expenses accounted for about 50 percent of the total of the 72 hospitals in 1958 and 1959 . . . the expenses of these five departments move closely with one another linearly and are also very highly correlated with

In 1970 published results were again mixed. Berry found tentative evidence to support economies of scale within groups of hospitals classified by ownership. Three alternative methods of output definition used by Francisco all support similar or identical conclusions in favor of declining average costs. However, a study by Lave and Lave concluded that economies of scale probably do not exist, but if they do, their magnitude is weak.

Francisco (1970) using 1966 data for 4,710 hospitals compared the results of cost-output relationships using three alternative methodologies for adjustment of output homogeneity: weighted index of output following the methods proposed by Saathoff and Kurtz (1962) and Cohen (1967); case mix as proposed by Feldstein (1965); independent variables for facilities and services and stratified groups according to the number and specific combination of services and facilities available (Berry, 1967). Francisco concluded:

> Three seemingly different methods of analysis of the cost-output relationship, designed to take into account variations in facilities and services, were shown to yield either identicial or similar results. (1970, p. 330)

Economies of scale were found for small hospitals but not for larger bed size groups suggesting an L-shaped long run cost curve for the hospital industry. Francisco notes that

> . . . groups of homogeneous hospitals having four or less of sixteen facilities and having an average size of under 70 beds exhibit economies of scale. . . . In the less homogeneous group (by number of facilities only) of

> 4,710 hospitals, groups having eight or less facilities and an average of 135 or less beds were shown to have significant economies of scale while the groups of larger hospitals did not. (p. 332)

Lave and Lave (1970) armed with 14 semiannual observations on 74 Pennsylvania hospitals from 1961 through 1967 attempt a two stage estimation procedure of time series and cross sectional data to explain variation of costs among hospitals. The first stage estimation procedure involves fitting a times series regression of average cost per patient day to independent variables including measures of utilization and hospital size. A vector characterizing the product mix was assumed to be constant for each hospital over the seven year period. The estimated equation was the generalized Cobb-Douglas double logarithmic form as follows:

$$\log AC_{it} = a_{i0} + a_{i1} + a_{i2}\log U_{it} + a_{i3}\log S_{it} + e_{it}$$

where AC is average cost per patient day, t is time, U is occupancy rate, S is the number of beds, e is the error term for each of the i hospitals and the a's are the estimated coefficients. Stage one was completed by estimating the above equation for each of the 74 hospitals.

Stage two followed by estimating functions designed to capture the variation in each of the a_i coefficients estimated in stage one above. Thus, for example,

$$a_{i1} = b_o + b_1\log S_{io} + b_2P_i + b_3M_i + b_4AT_i + b_6\log AC_{i0}$$
$$+ b_7\log U_{i0} + e_{it}$$

where P and M are dummy variables indicating the hospitals' locations (Pittsburg, other urban or rural) and AT and T are dummy variables representing the hospitals teaching status.

The authors report tentative results from analysis of the two stages, however, their ". . . attempts to analyze the a_{i3} (scale variable) proved completely fruitless." Second stage regressions were unable to explain more than about 23 percent of the total variation in any of the estimated equations although some individual coefficients were statistically significant.

An alternative approach was taken in which the time series and cross sectional observations were pooled into a single sample. The authors caution that care must be taken in pooling data:

> If the individual cost functions are not identical, the pooled regression can be useless in that it fails to explain a significant amount of variation or it can be misleading in that its coefficients are quite different from the coefficients estimated in the individual regressions.

Using the F test to test the hypothesis that the pooled regression explains as much variation after accounting for the increased number of degrees of freedom, the authors conclude that explanatory power is lost by ". . . forcing all five estimated parameters to be identical across hospitals." (p. 389) However, upon comparison of the estimated coefficients from the pooled regressions with the individual regressions, the authors conclude that ". . . pooling the data does not represent a great loss in explanatory power and does add to the possibility of richer models since the number of observations increases." The coefficient of multiple determination increased to .855 or higher for the pooled samples. (p. 391)

The authors conclude that ". . . the short-run average cost curve is L-shaped and . . . marginal cost . . . is between 40 and 65 percent of average cost." (p. 391) While these results differ from those found by P. Feldstein (1961) who estimated marginal costs as 20 percent of average costs, no real contradiction exists since Feldstein used monthly data while the Laves' study used semi-annual data. With respect to economies of scale, the results indicated ". . . that if economies of scale exist in the hospital industry, they are not very strong." (p. 394)

Berry and Carr (1973) in what is perhaps the most complete study of aggregate hospital data analyzed 1965 and 1966 data for all United States hospitals and for three hospital groups categorized by control: voluntary, government and proprietary. The authors conclude that

> . . . albeit hospital services are produced subject to economies of scale, the absolute and relative magnitudes of the potential savings are such that they probably do not provide much of an incentive for exploitation. In fact, these cost estimates are exclusively in terms of internal money costs and take no account of travel costs or the costs associated with inconvenience to patients, attending physicians, or visitors. (p. 28)

Several studies have focused on specific hospital departments, wards or services for which more complete data sets were obtained. The results of these studies indicate that significantly larger magnitudes of economies of scale exist in some services but not in all services. One of the earliest was a study of obstetrical facilities in the New York City metropolitan area (Hospital Review and Planning Council, 1965) which recommended that

> Maternity departments should be large enough to permit at least 2,000 births annually which would require 36 to 40 obstetrical beds per institution. Exceptions may be required in the less populous areas of the region. However, even in these areas, maternity programs should be coordinated to achieve effective use of specialized personnel and facilities. (p. i)

The recommendations were based on New York City Health Code requirements for a minimum of 11 registered nurses per day for any hospital operating a maternity ward.

> Efficiencies in staffing patterns appear as the volume of births increases. However, the savings in nursing personnel resulting from increased volume are proportionately less after 2,000 births have been reached.
>
> For the year 1964, the percentage of bed occupancy for individual maternity units was proportionately higher at hospitals with larger numbers of obstetrical beds and annual admissions. The occupancy rate ranged from 30 percent of capacity at institutions with 500 live births or less, to 74 percent at hospitals recording 2,000 to 2,499 births. The composite occupancy rate for hospitals reporting fewer than 2,000 births was approximately 54 percent. For the obstetrical programs reporting more than 2,000 births the rate was 71 percent. . . . (p. 9)

Kushner (1972) using 1965 data from 95 Ontario hospitals finds a U-shaped cost curve for hotel type services within the 300 to 500 bed range. Regressing total costs of hotel services on patient days adjusted for occupancy and size, the author found economies of scale in excess of 20 percent of the minimum average cost. Setting an index equal to 100 at minimum cost, Kushner reported 20 percent higher costs in 50 bed hospitals and 21 percent higher costs in hospitals of 800 beds. Using total patient days as the output measure for various services, optimum hospital sizes range from a minimum of 345 beds for housekeeping services to 560 beds for general nursing.

Fox (1973) estimated average cost functions for three services, obstetrics, emergency room and nuclear medicine, for a sample of Virginia and Maryland hospitals (1970 data). In the obstetrics analysis, inconclusive results were reported with respect to scale economies because of an inability to separate size from product mix variables. The variable for hospital complexity, ". . . the ratio of the number of the functions or departments of the given hospital over the total possible functions a hospital may have . . .," which also measures scale, was statistically significant with the correct sign although the output measure (deliveries) was not significant. (p. 75) Regression of total cost functions resulted in opposite results: the number of deliveries (output) appeared significant while the complexity variable was not.

Both emergency room and nuclear medicine involved smaller samples of 31 and 28 hospital departments respectively all of which were of larger than average hospital size since these services are not usually found among hospitals of less than 400 beds (Berry, 1973). Returns to scale were found in both of these services with decreases observed at any level of output.

Difficulties in measurement have precluded an adequate proxy for managerial efficiency. (Berry, 1970, p. 70) Kaitz (1968) concludes

> . . . that the hospital industry has not yet developed any normative standards for judging or evaluating its managerial performance. . . . Prices and costs are evaluated on a relative, not absolute, basis; the industry is not concerned with its level of prices and costs just so long as the prices and costs in one hospital are within the range of those in similar or nearby hospitals. (p. 88)

Nix (1974) in a study of managerial behavior in Oklahoma hospitals reported that ". . . managers in hospitals of different size categories have significantly different backgrounds and perceptions of the hospitals in which they work." (p. 151)

Level of education and number of years of experience were positively related to hospital size. However, the "warmest hospital atmosphere was found in small hospitals. Department coordination effectiveness was rated lower in the largest hospitals." (p. 151) Thus, managerial efficiency in terms of output reflects the tradeoffs among complexity and scope of managerial tasks, working environments, as well as size and other possible influences.

Starkweather (1970) applied stepwise multiple regression techniques to 1966 data on 704 acute care general hospitals to determine the relationships of size to hospital complexity and professionalization. He concludes that size is first related to scope of services offered, which is considered a proxy for complexity, and complexity is related to a high proportion of administrative persons. Thus, if product mix is held constant there would probably be an inverse relation between size and administrative overhead. (1970, p. 333)

Starkweather also observes that management qualifications, which may strongly influence organizations, vary with size. Administrators of larger hospitals are better trained and more experienced than their counterparts in small hospitals. Starkweather concludes that large hospitals run a smaller chance that outmoded or inappropriate policies and procedures will be sustained beyond their usefulness (1970, p. 333). However, in small hospitals a single informal performance-control network spans the entire institution, while in large hospitals several informal networks develop, a condition, he concludes, that leads to suboptimization of overall organizational control.

Organizational theory suggests that the relationship between size and organizational performance is not clearly predictable. Certain tendencies appear to exist among a variety of influencing variables, which leaves the conclusion that size is related to organizational performance at best uncertain in magnitude and direction. Thus, while it may be accepted that larger hospitals employ administrators who are better trained and have more experience than administrators in smaller institutions, the conclusion that or from the addition of another product line. Where costs and output measure the latter type of change, economies of scale in production of the first product line will be incorrectly estimated. There does not appear to be an empirical concensus, however, on the degree of economies of scale nor on the range over which average costs decline for the aggregate output of the hospital.

Those studies of departments, services or other functions of the hospital, while more limited in number, yield results consistent with theoretical predictions. The degree of returns to scale depends on the particular function or department. Substantial magnitudes of economies of scale exist in some services but not in all services.

The findings that a hospital size expands in a sequential manner by adding additional services, i.e., product lines, is also consistent with the theory of a multiproduct firm which expands its product mix in response to changes in demand.

CHAPTER IV

MULTIHOSPITAL ARRANGEMENTS IN THE HOSPITAL INDUSTRY

Cooperative arrangements among firms to achieve economic advantages have long been accepted as viable organizational alternatives among industries through the world. The hospital industry is no exception, although the number of formal cooperative arrangements among hospitals in existence prior to the 1970's was quite small. However, during the past ten years there has been a significant increase in both the acceptance of the feasibility of cooperatives and in the number of formal multihospital organizations. This chapter presents the institutional aspects relevant to the development of multihospital organizations and of the hospital cooperative studied in this thesis, Medical Products Systems, Inc. (MPSI).

The nature of hospital production and the extent of the market are important factors which influence the size and distribution of hospitals and may affect the development of cooperatives. In addition are other forces such as increased demand for hospital output and associated changes in costs of factor inputs, the market structure of hospital supplies, and the role of government in promoting multihospital arrangements. The concluding section of this chapter discusses barriers which inhibit the development of hospital cooperatives.

Hospital Output and Extent of the Market

The multiproduct output of the hospital industry may be viewed as a bundle of intermediate products and services which when combined with physician services in the hospital setting are "health care" consumables. The mix of consumables produced by the hospital includes a range of services such as diagnostic, custodial and therapeutic care.[1] The hospital must be prepared to provide some minimum mix of different services[2] in order to meet a variety of contingencies for patient diagnosis, maintenance and treatment during hospitalization. Physicians and other professional staff members of the hospital select combinations of intermediate products and services in relation to the conditions characterizing a patient's illness. The minimum bundle or product mix can be considered a joint product at the point of

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[1] Berki lists seven classifications of services provided by general hospitals: preventive, diagnostic, therapeutic, maintenance, ameliorative, research, and medical education. (1972, p. xvii)

[2] Legal requirements may require a minimum product mix. For example, to obtain a hospital license in the state of Oklahoma obstetric facilities must be provided despite the volume of births occurring within the hospital. (Oklahoma Department of Health, Hospital License Regulations, 1975). Furthermore, accreditation standards by the Joint Commission on Hospitals and federal safety and health regulations impose a variety of minimum standards on the hospital. (Occupational Safety and Health Administration, 1970.)

consumption by the patient although each of the component products may be produced independently at earlier stages of production. Since the consumption of hospital output takes place within the hospital over a continuous period of time where the consumer (patient) physically comes in contact with the physician and hospital services, the hospital market area is circumscribed and limited by travel time and distance. (Klarman, 1975, p. 8) The urgency of admission and uncertainty surrounding the nature of the patient's illness also places a premium on the cost of time and convenience of location of the hospital to the patient and family. These distribution requirements for consumption of the hospital product is a primary influence limiting the extent of the market place.

Delivery of hospital services within local markets is reflected by the size distribution of hospitals observed in the nation. The hospital industry in the United States comprises more than 6,000 acute care general community hospitals serving geographically dispersed populations in local markets. Three fourths of the community hospitals are smaller than 200 beds while the majority of the smaller hospitals are located in non-urban, relatively sparsely populated regions which are often referred to as a "rural" environment. (Pettingell, op. cit., p. 12) The distribution of community hospitals in 1974 by size measured by number of beds and characteristics of hospitals by geographic location are shown in Tables 3 and 4 for the United States, Oklahoma and M.P.S.I. member hospitals. In urban areas of high population density several hospitals of up to 1,000 or more beds may be found serving essentially the same geographic market area. In the more rural areas of sparse population density communities of fewer than 10,000 population will usually be served by no more than a single small hospital.

In Oklahoma for example, 122 community hospitals served a total estimated state population in 1970 of 2.67 million persons, or an average of 21,885 persons per hospital. The number of licensed beds provided by the 122 hospitals totaled 11,305 representing an average of 236 persons per bed. In terms of definable population centers, or catchment areas, there are 88 separate population areas served by one or more hospitals. In addition to SMSA's, which are served by 34 institutions, nine communities have populations greater than 20,000 and six have populations of between 10,000 and 20,000. More than 70 hospitals serve single towns whose urbanized populations are less than 10,000 although each hospital may serve a somewhat larger population from the surrounding rural residents. Estimates of the population served made by hospital administrators interviewed in northeastern Oklahoma indicate that most smaller Oklahoma hospitals serve between 10,000 and 20,000 residents. (CEMR, 1976, upublished data).

TABLE 4

CHARACTERISTICS OF SHORT TERM COMMUNITY HOSPITALS BY GEOGRAPHIC LOCATION: S.M.S.A. AND NON S.M.S.A. IN U.S., OKLAHOMA AND SELECTED S.M.S.A.'S, 1974

Geographic Location	Number Hospitals	Number Beds	Occupancy Rates Percent	Average Length of Stay in Days
Oklahoma (Total)	122 (100.0%)	11,200 (100.0%)	70.2%	6.8
Non-S.M.S.A	84 (68.9)	5,222 (46.6)	63.5	6.5
S.M.S.A.	38 (31.1)	5,978 (53.4)	76.1	7.0
Tulsa	15 (12.3)	2,331 (20.8)	75.2	7.5
Okla. City	21 (17.2)	3,233 (28.9)	78.1	6.7
Lawton	2 (1.6)	327 (2.9)	70.3	6.2
U.S. (Total)	5,789 (100.0%)	897,830 (100.0%)	75.7	7.8
Non-S.M.S.A	2,939 (50.8)	241,015 (26.9)	69.4	7.2
S.M.S.A.	2,850 (49.2)	656,115 (73.1)	78.0	8.0
M.P.S.I. Member Hospitals	15 (100.0%)	2,449 (100.0%)	67.8	6.9
Non-S.M.S.A.	13 (86.6)	1,455 (59.4)	69.2	6.3
S.M.S.A.	2 (13.4)	994 (40.6)	68.6	10.8

[1]Table 6, Hospital Statistics, 1975 Edition, p. 17.

TABLE 5

OCCUPANCY RATES BY BED SIZE CATEGORY: M.P.S.I. MEMBER, OKLAHOMA AND U.S. COMMUNITY HOSPITALS, 1974 (IN PERCENT)

Hospital Bed Size Category Number Beds	Occupancy Rate		
	M.P.S.I. Members[1]	Oklahoma Hospitals[2]	U.S. Community Hospitals[2]
6 - 24	65.2	47.2	48.4
25 - 49	62.4	57.0	56.5
50 - 99	66.7	63.1	65.4
100 - 199	61.3	74.6	71.8
200 - 299	74.9	79.7	77.4
300 - 399	89.3	70.4	79.9
400 - 499	NA	84.5	81.3
500 or more	78.7	80.9	81.8
ALL SIZES	67.8	70.2	75.3

[1]Unpublished data reported by hospitals on survey (CEMR, 1976).

[2]Table 3, Utilization, Personnel per Census, and Finances per Patient Day, in Hospital Statistics, 1975 Edition, American Hospital Association, Chicago, c. 1975, p. 10.

compared to 62 and 222 for the secondary and tertiary care institutions, respectively. The short run effects of the departure, for example of one of eight physicians in the rural area has proportionately greater consequences for occupancy in the small hospital.

The larger number of single town hospitals serving local markets in low population density areas compared to many hospitals serving markets of larger population densities suggests that the scale of production of the smaller single town rural hospitals, restricted by effective demand, may be operating on the declining segment of the long run average cost curve. Under this assumption, potential for lowering unit costs of production depends on growth in effective demand or on improvements from reorganization of existing modes of production.

Potential for Improved Cost Efficiency

Increased demand may allow the hospital to lower unit costs by increasing production of existing product lines, by changing the product mix, or both. For example, following growth in demand hospitals may expand product mix without altering output in any existing product line because of the existence of potential economies of scale in the use of inputs common to the production of the new and old product lines. Alternatively, output could expand within a single product line without a change in product mix. If market demand is divided among two or more hospitals, reduction of product mix could enable hospitals to specialize in a fewer number of product lines and achieve potential economies in the use of specialized inputs. Examples of the latter case are burn centers and premature nurseries.

In the case of a hospital facing a limited market, such as in a rural community, improved cost efficiencies from expanded scale may not be justified by effective demand. Further reductions in scope of product mix may be either undesirable or not possible if product mix is already at the minimum. For these hospitals, reorganization of the mode of production without altering product mix or scale of production may present the only potential source for improved cost efficiency.

Hospitals may obtain potential economies from reorganization of production by delegating declining cost functions and activities to specialized firms in an auxiliary industry. Chapter II presented the theory of cooperative arrangements as an example of an externality in production obtained by individual firms as a result of expansion of the industry. The following section discusses recent increases in industry demand and the market structure of medical equipment and supplies which are relevant to the development of cooperative arrangements in the hospital industry.

TABLE 6

SOURCES OF INCOME REPORTED BY 18 M.P.S.I. AREA HOSPITALS FOR 1974

Hospital Identity	No. Beds	Percent of Total Income				
		Medi-caid	Medi-care	Other 3rd Party	Private Pay	Charity
1	25	11.0	46.0	(	43.0	)
2	25	7.6	54.2	(	38.2	)
3	25	10.0	58.0	(	33.0	)
4	26	8.0	44.0	37.0	7.0	4.0
5	33	4.6	52.4	(	39.5	)
6	42	3.8	48.5	42.8	5.4	.1
7	42	7.0	59.0	32.0	2.0	3.0
8	50	4.8	45.4	6.6	43.2	NA
9	54	3.0	62.0	26.0	9.0	NA
10	77	15.0	47.0	30.0	3.0	5.0
11	85	10.2	34.0	50.0	5.6	.4
12	101	13.9	43.0	33.1	6.0	4.0
13	107	10.0	38.0	41.0	11.0	0.0
14	116	10.0	40.0	35.0	10.0	5.0
15	119	8.0	34.0	46.0	12.0	NA
Avg[1] of 1-15	62	8.5	47.1	(	44.6	)
16	246	4.0	40.0	45.0	8.0	3.0
17	541	9.6	28.7	38.5	20.6	2.6
18	552	10.0	40.0	28.0	9.0	13.0
Avg[1] of 16-18	446	7.9	36.2	(	55.9	)
Avg of 1-18	126	8.4	45.3	(	46.3	)

Source: CEMR, 1976, unpublished data.

[1]Averages of Columns.

of 203 percent in gross national product for the nation.

Increased earnings per employee reflects in part the extension of minimum wage legislation to the hospital industry beginning in 1968. The value of plant assets per patient census approximately doubled during the decade reaching an average of nearly $32,000 per census in 1971. In all cases mentioned above, growth rates were substantially higher during the second five year perior of 1966-1971. (Pettingill, 1973, p. 8)

The Market for Medical Equipment and Supplies

In addition to using large labor inputs in the hospital production process, the hospital purchases a wide variety of medical equipment and supplies. A recent study of the medical equipment and supply industry described the industry as "a partial, differentiated oligopoly . . . a few big firms followed by a crowd of small ones." (Peterson, 1973, p. 189) Interaction between buyers and sellers in the market is summarized by the authors as follows:

> The structure, conduct, and performance of buyers and sellers in this sector interact in six ways. These are: (1) rising prices and relatively high profits stem from increased demand for medical equipment and its relative price-inelasticity of demand; (2) large scale economies in selling medical equipment, coupled with buyer ignorance, allows firms to practice product differentiation; (3) buyer susceptibility to minor product variation inspires little meaningful innovation by sellers; (4) buyer independence on maintenance and repair, together with the technical complexity of medical equipment, allows sellers to differentiate the product; (5) the existence of many small, suboptimal buyers allows sellers to integrate vertically into

> selling and service; and (6) imperfect knowledge, dependence on brand names, and post-sale service practices cause difficulties of entry. (Ibid., p. 188)

The authors conclude that ". . . improvements in buyer performance form a necessary condition for better performance in medical-equipment and supply-markets." Recommendations included such measures as community planning for hospital facilities and equipment, better manpower training, improved product specifications, and better market information. (Ibid., p. 190) Cooperative purchasing is perhaps the function found most frequently although the extent of multihospital arrangements today is considerably broader.

The Extent of Multihospital Arrangements Today

Although the concept of cooperative arrangements has circulated within the hospital industry since the 1920's, few examples of formal interhospital arrangements occurred prior to the late 1960's. (Astolfi and Matti, 1972) Since then, a strong movement towards formal cooperatives has been observed within the United States and Canada. The current status of multihospital relationships reflects two trends, one toward merger where a hospital's identity is lost and second toward the wide array of multihospital relationships which preserve hospital identity. Doody (1974) reports the results of a hospital survey of multihospital arrangements. Of the 4,854 hospitals which responded to survey questions, 845 or 14.7 percent indicated participation in a multihospital system. Of those participating, 57 percent belonged to a religious chain or investor owned or merged systems. Other forms of multihospital arrangements which accounted for the remaining 43 percent represented affiliation agreements, management contracts or other relationships. Investor owned hospitals participating in multihospital systems, which represented nearly 26 percent of all for-profit hospitals responding to the survey, showed the highest rate of membership in multihospital system classified by ownership or control. Membership classified by hospital size categories indicated that small hospitals participate in cooperatives less frequently than larger hospitals. In all, the survey identified 350 separate multihospital arrangements. Data were insufficient, however, to determine the age of the systems nor the breadth of activities. (Doody, 1974)

In 1974 approximately 13 percent of all hospitals were investor owned for-profit institutions while 30 percent were owned by state, municipal or county government and the majority of 57 percent were nongovernment not-for-profit institutions.[3] Table 7 summarizes ownership of

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[3]Unpublished minutes of a quarterly conference among the directors and staff of the five shared service corporations in Oklahoma held December 19, 1975 as reported by Oklahoma Regional Medical Program.

community hospitals in the U.S., Oklahoma and membership in Medical Products Systems, Inc., in 1974.

Another study (Astolfi, 1971) attempted to identify the extent of hospital sharing by individual services. Sharing a service was defined to exist "if (the hospital) works with one or more other hospitals to: (1) pool manpower or capital resources, (2) make services and facilities available through planning, and (3) make a joint purchase of services or products." Of the 4,725 reporting hospitals (82.5 percent of those surveyed) two-thirds reported sharing of at least one of the 99 possible services. In all, 29,419 instances of sharing were reported with a like number of instances in which interest in sharing was expressed. The average number of services shared was 6.2 per hospital with a median reported of 7.0 services per hospital reported. (Astolfi, 1972)

In a review article Starkweather comments that although Astolfi and Matti report sharing of some form by over half of all community hospitals, sharing is limited in most cases to logistical and administrative support activities of little real importance to crucial hospital operations. (Starkweather, 1973) He further concluded that the prevailing state of knowledge with respect to mergers and shared services is a ". . . basic but unverified belief that aggregation of services would lead at least to increased efficiency and perhaps to improved effectiveness. . . ." (Starkweather, 1973, p. 67)

In virtually all of the documented cases in which formal multihospital systems have occurred, an external agency or organization, usually a charitable foundation or a government agency, has provided the funding and organizational assistance during the formative months or years of the arrangements. Based on 16 case studies of shared service arrangements conducted during 1975, Matti reports that ". . . Regional Medical Programs appear as the strongest governmental impetus . . . while the Hill-Burton program has, on occasion, acted as a stimulus to sharing." Comprehensive Planning agencies played a minimal role in the 16 cases studied. (Matti, 1976, pp. 33-34) The exceptions are those in which institutional autonomy of at least one party has been dissolved as in the cases in investor owned chains, religious affiliations and mergers.

Federal Government Involvement

Proposals for integrating hospital facilities within regional hospital networks were proposed in Congressional hearings as early as 1932. It was not until 1946, however, that congress passed the Hospital Survey and Construction Act of 1946 (Public Law 79-725), commonly referred to as the Hill-Burton program. The law provided that grants be given to the state for two purposes:

(1) to assist in a survey of state needs and to develop state plans for the construction of public and other voluntary nonprofit hospitals and public health centers, and

(2) to assist in building such facilities.

Lave and Lave summarize its accomplishments since 1946 as:

> The Hill-Burton program has financed a small (usually less than 15 percent) but significant proportion of annual hospital construction. The program has increased the number of hospital beds, especially in small cities, so that beds are no longer concentrated in the richer states. It has also helped hospitals to modernize, and has been influential in the development of state and regional planning for hospital care. (Lave and Lave, 1974, p. 2)

Following the Hill-Burton program it was not until enactment of the Regional Medical Program and state and local area Comprehensive Health Planning laws that the federal government became more actively involved in promoting integration of hospital services. Up to this time government expenditures and programs had not provided public funds to develop formal multihospital relationships.

Pursuant to Public Law 89-239 of 1965, 55 Regional Medical Programs were established in the United States within which planning and development funds were provided for the expressed purposes as follows:

> (a) through grants, to encourage and assist in the establishment of regional cooperative arrangements among medical schools, research institutions, and hospitals for research and training (including continuing education) and for related demonstrations of patient care in the field of heart disease, cancer, stroke and related diseases.
>
> (b) . . . to improve generally the health manpower and facilities available to the Nation and to accomplish these ends without interfering with the patterns, or the methods of financing of patient care or professional practice, or with the administration of hospitals, and in cooperation with practicing physicians, medical

> center officials, hospital administrators, and representatives from appropriate voluntary health agencies. (Public Law 89-293)

Paragraph (b) above clearly expresses the intent for minimal conflict of the legislation with existing arrangements of control and professional practice.

Two examples of formal multihospital services funded in part by the Oklahoma Regional Medical Program are coronary care monitoring and the continuing education teleconference systems. First, the coronary care monitoring system which began in 1969 provides cardiac patients located in outlying hospitals with continuous remote monitoring of vital signs by cardiology specialists located in the intensive cardiac care unit of a larger more specialized hospital.

Inservice education centers are a second interhospital system which tie together rural and urban hospitals within a closed network of dedicated telephone lines providing two-way talk back lectures and conferences among remotely located hospitals. The teleconference system, which established an interhospital communication network and opened channels of information flow among hospital administrators and staff, is thought to have been an important enabling step for the subsequent establishment of the five shared hospital service corporations in Oklahoma.(CEMR, 1976, unpublished data) Currently, four of the five regional teleconference networks in Oklahoma are integrated as a shared education service into the respective regional hospital corporations. Combined, all five networks connect 96 of the 123 Oklahoma community hospitals within a statewide continuing education system. (CEMR, 1976, p. 38)

Comprehensive Health Planning Legislation (Public Law 89-749) of 1966 was intended to implement past recommendations for local and statewide planning organizations, however, the legislation did not provide for specific areas in which health planning was to occur. (Yordy, 1975, p. 206) Klarman describes the prevailing sentiment toward planning:

> In the hospital industry, unlike most other areas of economic activity in this country, the 1960's have witnessed a widespread movement toward external planning and coordination. Absence of coordination in hospital facilities and services is seen as the "face of anarchy" and as evidence of the lack of any system.
>
> Experts, officials, and the public expect that planning and coordination will reduce the cost of hospital care or at least curtail its rise in the future . . . by (a) limiting the number of beds; (b) avoiding . . . duplication . . . (c) by establishing cheaper substitute facilities and services. (Klarman, 1965, pp. 136-137)

The major restriction of the CHP program was the inability of the planning organizations to do more that encourage health institutions and other health providers to cooperate and coordinate. Neither regulatory authority nor funding were provided for implementation of plans developed by CHP agencies. Actions to hold individual institutions accountable to the limits of the regional or state plan were limited to review and comment without punitive authority. (Yordy, 1975, p. 286)

The National Health Planning and Resources Development Act of 1974 (Public Law 93-641) eliminated the Hill-Burton, CHP and RMP programs and re-established their primary functions under a new organizational structure. Several of its priorities refer specifically to provisions shown in Appendix C, which are supportive of multihospital arrangements. (Yordy, 1975, p. 211) In discussing the prognosis for the new legislation Yordy concludes:

> The regulatory authority provided in the new legislation is focused on capital expansion and federal grant programs. Such authorities would seem to be useful in shaping the direction of new activities but not very effective in influencing the organization of existing institutions and programs. The achievement of a regionalized system through authority over new activities would probably take many years. Primary reliance in achieving regionalization would still be based on assembling and disseminating data, publicizing plans and recommendations, and the persuasive capacities of the health systems agency. (Ibid., p. 214)

Emergence of MPSI as a Formal Cooperative Venture

The development of MPSI as a formal multihospital corporation has its origins in previous cooperative experiences among two or more area hospitals dating back as far as 1968. By 1968 a 300 bed hospital with a full time pharmacy staff including registered pharmacists was providing a satellite pharmacy service to a 32 bed hospital located 42 miles away. The administrators of the small hospital reported that as a result of the cooperative arrangement pharmacy inventory levels were reduced by more than 50 percent in dollar value and a hospital experienced registered pharmacist was for the first time available to consult and supervise his pharmacy service on a routine basis. (CEMR, 1976, unpublished data)

In 1970 twelve regional hospitals in the MPSI area established a Continuing Education Center (CEC) and teleconference system in Bartlesville, Oklahoma with the financial assistance of the Oklahoma Regional Medical Program. The CEC became one of the M.P.S.I. services in mid-1973 when continued funding by ORMP became questionable. CEC programs include scheduled seminars and classroom lectures for more than 31 hospital occupations and professional manpower categories ranging from housekeeping procedures to medical and dental education. One of the major advantages claimed for the system is that hospital staff are able to participate in continuing education programs, some of which are required for licensure, without leaving the premises of the hospital. (CEMR, 1976, p. 23)

Following the completion of a shared services feasibility study in 1971, seven area hospitals incorporated MPSI in December of 1972. The first service, group purchasing of intravenous products, realized between 5 and 25 percent cost reductions from previous contract prices of individual hospitals. (CEMR, 1976, p. 29) Further improvements in group contracts occurred as the volume of the cooperative grew from the addition of more hospitals. By the end of 1974 group purchases of intravenous products had

Financing of the various services has included a variety of methods dependent on the nature of the products or service. For example, hospitals were charged a fixed fee per hospital bed to support the CEC service regardless of the amount of hospital participation. Mark ups above cost which averaged about 8 percent for drugs and intravenous products generated revenue from the sales of drugs and intravenous products. Financing of inventory growth was accomplished by contributions from member institutions to a capital fund. An initial membership fee of $10 per licensed hospital bed was required for each institution. In addition, federal subsidies in the amount of $111,000 received from the Oklahoma Regional Medical Program represented 23 percent of total sources of funds during the first two years of the cooperative's existence. (CEMR, 1976, p. 32)

The cooperative structured its mark ups in accordance with size of hospitals and the size of quantity discounts obtained by group purchasing. For example, since the larger urban hospitals obtained lower unit costs than the smaller rural hospitals, the cooperative priced its products on many items by establishing a base or minimum mark up after comparing its quantity discount to the lowest prices paid by any member. An additional mark up of from 2 to 10 percent was charged to the smaller hospitals as size decreased.

Barriers to Entry and Visible Incentives

The cooperative received encouragement in its formative period because of previous successful experiences in cooperative arrangements, the belief that potential cost savings could be realized, for example, from group purchasing and from inventory reductions, and the desire to improve existing systems such as the introduction of the unit-of-use drug system which has been accepted by the American Society of Hospital Pharmacists as the preferred drug system based on quality and safety of drug administration to the patient. (1972, p. iii) In the pharmacy service, no commercial alternative supply of unit dose packaged drugs was available even to larger urban hospitals. The only alternative was in repackaging by the hospital those items not available in unit dose from drug manufacturers. In addition, the cooperative chose as its executive director a registered pharmacist who not only was experienced in hospital pharmacy but who also had directed the local satellite pharmacy program during the previous 4 years and had played a major role in completing the initial feasibility study.

On the other hand during the first two years of operations, many organizational barriers to integration were encountered. Preservation of local interests, suspicion toward outsiders such as consultants or government representatives, inadequate information, ill perceived organizational goals, and competition among independent institutions within a market area are other examples of organizational barriers inhibiting institutional integration encountered by M.P.S.I. (CEMR, 1976, unpublished data). Furthermore, the division of hospital authority within the "triumvirate" of the hospital board, medical staff and administrator is thought to be a major barrier. (Georgeopoulos, 1972, p. 311) This organizational barrier may suggest a tendency for emerging cooperatives to develop most rapidly within the functional areas controlled by the initiating parties. For example, administrators of M.P.S.I. expressed the goal of pursuing cooperative activities which minimized involvement of the medical staff. (CEMR, 1976, unpublished data)

Hospital cooperatives may also encounter limits to their maximum size for other reasons. For example, too large a size may bring into effect federal regulations, inspections, and other requirements not applicable to smaller scale operations. The situation encountered by MPSI and at least one other hospital shared service group in Kentucky is the requirement of the Federal Drug Administration that repackagers maintain a full time inspector on the premises during the repackaging of bulk to unit dose drugs. Presumably, at some point the FDA criteria for requiring a full time quality inspector is related to volume of activity. As long as the cooperative is repackaging at volumes which approximate that which hospitals might individually repackage, FDA inspection requirements may not be applicable. But at some point, not clearly defined to the MPSI management, FDA presumably decides that the cooperative is not longer "an extension of the hospital." The effect of circumstances described above would be to cause a discontinuity in the average cost curve, raising that segment of the curve by the additional cost of meeting FDA regulations beginning at the production scale for which inspection requirements are enforced.

CHAPTER V

THE EMPIRICAL MODEL AND RESULTS

The hypotheses of this thesis are:

1. Production of hospital services at the functional or departmental level is characterized by different degrees of returns to scale which vary in magnitude over different ranges of output.

2. Cooperative arrangements are an organizational means for independent geographically dispersed hospitals to obtain economies of scale in those functions exhibiting increasing returns to scale over the range of production scale of the respective hospitals. That is, hospitals participating in cooperative arrangements in areas with declining cost functions experience lower average costs of production compared to nonparticipating hospitals.

3. Economic benefits from cooperative arrangements in declining cost functions will be relatively greater for the smaller and rural hospitals than the larger urban hospitals.

To test these hypotheses the degrees of returns to scale are estimated for three intermediate hospital products--pharmacy, dietary, and medical records--and the aggregate final output of a sample of acute care general hospitals located in the market area of the M.P.S.I. cooperative. The presence of substantial economies of scale in the production of intermediate products will be considered as evidence supporting the hypothesis that potential cost reductions can be realized from reorganization of the production of intermediate products. The relative cost efficiency of the cooperative arrangement in the pharmacy service will be indicated by member hospital average costs that are lower than average costs were prior to membership and are lower than average costs of nonmember hospitals.

Substantial increasing returns to scale in the production of final output would imply that specialization of hospital output through consolidation and expansion of scale of the aggregate output of hospitals is feasible. If the production of aggregate hospital output is subject to increasing costs, however, a reduction in the scale of the average hospital would be indicated.

The influence on the level of costs of additional factors associated with rural location and limited markets is considered by introducing into the estimated equations appropriate independent variables which distinguish the rural from the urban production environments. The structure of the cost function is assumed the same for all hospitals although levels of cost may differ.

Finally, the degree of improved efficiency obtained by the cooperative will depend on the actual economies of scale it achieves in its specialized production. A cooperative which experiences increasing returns to scale would cause member hospital cost curves to shift downward over time as the cooperative's scale expanded from growth in the number of its member hospitals. A comparison of hospital cost curves estimated from cross sectional data for a period of years provides an indirect assessment of the degree of returns to scale internal to the cooperative.

Derivation of the Estimating Equations

Assume that the hospital industry production function can be approximated by the generalized Cobb-Douglas form,

$$(1)\quad y_{ij} = \prod_{k=1}^{n} aZ_{ijk}^{\alpha_k}$$

where y_{ij} is the output of the ith service in the jth hospital, the Z_k are the n factor inputs, a is the technology constant, and the α_k's are the respective output parameters of the n inputs. The Cobb-Douglas total cost function drived in reduced form from equation (1) above under cost minimizing conditions is given by

$$(2)\quad tc_{ij} = a^1 \, y_{ij}^{1/r} \prod_{k=1}^{n} P_{ijk}^{\alpha_k/r}$$

where tc is total cost of the ith service in hospital j, P_{ijk} are the n input prices, $a^1 = r(a \prod_{k=1}^{n} \alpha_k)^{1/r}$ and $r = \sum_{k=1}^{n} \alpha_k$

where r is the returns to scale parameter. This form is consistent with variable factor prices possible for the j hospitals, each of which, however, produces subject to the same industry output, technology and returns to scale parameters in each of the i services.

In double logarithmic form the cost functions take the form:

$$(3)\ TC = A^1 + b_o Y + \sum_{k=1}^{n} d_k P_k + V$$

where capital letters indicate natural logarithms, $b_o = \frac{1}{r}$ and $d_k = \frac{\alpha k}{r}$ and V is a disturbance term. The subscripts i and j are dropped for notational convenience.

The form of the total cost function shown in equation (3) is advantageous for several reasons. First, the log linear property of the cost function is easy to estimate. Second, the cost function, as the reduced form of the production function, is its dual and uniquely identifies the parameters of the production function under the conditions that factor prices are included in the specification and managers are cost minimizers. (Nerlove, 1965, p. 10, 16n and 107) Third, the reduced form equation is the relationship between an endogenous dependent variable and exogenous explanatory variables. Thus, simultaneous equation bias is avoided if the explanatory variables included in the estimating equations are in fact exogenous.

If competition in factor markets prevails, factor prices are given to each hospital. Output may be assumed to be exogenously determined since community hospitals are held morally, and in some cases legally, responsible to accept all patients. This is similar to the case of a regulated public utility which is not allowed to restrict services to any consumer. (Nerlove, 1965, p. 102; Lave and Lave, 1970, p. 381n) The price inelasticity of demand for hospital care is also suggested as a reason for the exogeneity of output. (Lave and Lave, ibid.) Derived demand for the intermediate output of individual services is also exogenous if substitution among intermediate products does not occur. This assumption seems plausible in selected cases of acute inpatient care since, for example, pharmacy output appears to be complementary to and not substitutable for output from the dietary or medical records departments.

A disadvantage of using the Cobb-Douglas form is that the economies of scale parameter is constant across the entire range of output. Since it is quite probable that returns to scale will vary with output level, the original cost function was modified to include $r = f(y) = \frac{1}{b_1+2b_2\log(y)}$ with respect to output only, which accounts for the squared output term shown in equation (4). Thus, returns to scale can be evaluated at specific output levels. (Nerlove, op. cit.)

Consistent with the properties of the Cobb-Douglas production function each hospital is assumed to use the same production function whose parameters are assumed constant over time. Variable proportions of factor inputs are possible subject to constant elasticity of substitution equal to unity. Although the influence of factor prices does not affect the returns to scale parameter, the advantage of including factor prices lies in the more complete specification of the estimating equations and the additional information provided by direct estimation of the output parameters of the factor inputs. Further, excluding relevant variables from a regression would cause bias in the estimates of the coefficients of those included.

The Error Term

The error term V_{it} is assumed to be composed of three parts: the individual effect, the time effect and the remainder, respectively (Chetty, 1968, p. 280), so that:

(7) $V_{it} = v_i + u_t + e_{it}$

In a cross sectional study, V_{it} is assumed to be a random variate normally distributed with mean zero and unit variance if v_i and e_t are independent and also random normal variates. However, the individual effect v_i of the residual may be correlated across hospitals because of specific environmental factors such as participation in the cooperative organizations and differences in geographic location. To account for these environmental sources of residual correlation, specific environmental factors (E_m) are included in the estimated cost functions. Other individual effects, such as managerial ability or age of the hospital, are assumed to be randomly and independently distributed. The time residual u_t, which may be serially correlated in time series data, is accounted for by inclusion of a time variable (t).

Equation (8) is the form of the total cost function to be estimated for each of the four cost categories (pharmacy, dietary, medical records and total hospital costs) for each of the three years (1972, 1973, and 1974) and pooled samples of cross sectional data for 1972 and 1973, 1973 and 1974 and for the three year period.

$$(8)\quad TC = F + b_1Y + b_2Y^2 + d_1P_1 + \sum_{m=1}^{m} g_mE_m + t + e$$

where m is the number of environmental factors (E), g_m are the respective estimated coefficients, t is the time variable included in the pooled samples only, and e is the disturbance term. P_1 is the average annual wage cost per full time equivalent for each service. In pharmacy, a drug price index was included as a second factor price, P_2.

The primary advantage of pooling cross sectional data into a time series sample is to increase the number of degrees of freedom. Pooling of data in this manner is equivalent to assuming that all observations on cost, output and prices from all years are independent for each of the reporting hospitals. The appropriateness of this assumption is further explored in a later section under empirical results.

Average Cost Functions

For the purpose of comparing the results of this study with many of those found in the literature, average cost functions for each cost category were estimated. Specification of the estimating equations includes the same variables (not logarithms) as discussed under total cost functions. The general form is

$$(9)\ AC = c + a_0(\text{OUTPUT}) + a_1(\text{OUTPUT})^2 + \sum_{i=2}^{n} a_i(\text{FACTOR PRICES}) + \sum_{k=n+1}^{k} a_k(\text{ENVIRONMENTAL FACTORS}) + \text{error term}$$

where AC is average cost per unit of output (AC = Total Cost/Output), lower case c is the constant, and the a_i are estimated coefficients.

Returns to Scale

The existence of economies of scale over all or some range of output is indicated if the estimated coefficients (equation 8) b_1 and b_2 have the correct sign and are statistically significant at the .05 level of confidence. If the nonlinear output coefficient, b_2, is significant, the magnitude of the estimated returns to scale at a given level of output is estimated by calculating the returns to scale parameter, r, where

$$r = \frac{1}{b_1 + 2b_2\log(\text{output})}$$

An r value greater than unity indicates that economies of scale exist at the respective output level while an r value of less than unity indicates diseconomies of scale.

If the coefficient b_2 is not significantly different from zero, total costs increase in a fixed proportion to output over the entire range of observed scales. In this case, the magnitude of returns to scale depends only on the linear output coefficient b_1 such that

$$r = \frac{1}{b_1}$$

An r value significantly greater than unity (b_1 significantly less than unity) indicates the presence of economies of scale over the entire production range; b_1 significantly different from unity, however, suggests the condition of constant returns to scale in production.

If the average cost function is estimated directly (equation 9) and the sign of a_0 is negative, the effect of a_0 is to cause the average cost curve to be downward sloping in some range of output. If a_1 is positive and is coupled with a negative a_0, a U-shaped average cost curve is indicated. A negative sign for a_1 indicates average cost continues to decrease as output expands over the output range considered. An apparently perverse result, encountered in some studies including this one, is the inverted U-shaped average cost curve which occurs when a_0 has a positive sign and is combined with an a_1 coefficient with a negative sign.

Definition of Variables and Interpretation of Results

Table 8 defines all variables included in the study and gives the statistical acronyms used in the estimated equations and data sources. This section discusses the meaning of independent variables used and interpretations and the expected signs of the estimated coefficients. Table 9 shows the form of the estimated equation for each of the four cost categories and the expected signs of estimated coefficients.

Output Proxies

In the aggregate hospital and pharmacy services output was defined as the number of patient days per 12 month fiscal year (PTDAYS). In medical records the number of annual discharges (DISCHG) and in the dietary service the number of meals served per year were output variables. The number of patient discharges was also used as an alternative to patient days.

Factor Prices

For each service the average cost of labor was determined by calculating the ratio of total wage costs to the number of full time equivalent personnel reported in the respective cost category. These variables are defined as

TABLE 8

LISTING AND DEFINITIONS OF DEPENDENT AND INDEPENDENT VARIABLES

Variable Name	Definition of Variable	Natural Logarithm of Variable (If Applicable)	Source[1] of Data
Dependent Variables:			
TCHOSP	Total annual operating expenses of hospital	LGTCHO	1,2
TCPHAR	Total annual operating expenses of pharmacy service	LGTCPH	1
TCDIET	Total annual operating expenses of dietary department	LGTCDI	1
TCMEDR	Total annual operating expenses of medical records department	LGTCMR	1
ACHPTD	Average total hospital cost per patient day during a year (TCHOSP/PTDAYS)		*
ACHSTA	Average total hospital cost per patient stay during a year (TCHOSP/DISCHG)		*
ACPHPD	Average cost per patient day of pharmacy service (TCPHAR/PTDAYS)		*
ACMEAL	Average cost per meal in dietary department (TCDIET/MEALS)		*
Independent Variables:			
Output Measures:			
PTDAYS	Total annual number of patient days; i.e., the average number of occupied beds per day times 365 days per year.	LOGPTD	1,2

TABLE 8--Continued.

Variable Name	Definition of Variable	Natural Logarithm of Variable (If Applicable)	Source[1] of Data
PTDAY2	PTDAYS squared	LGPTD2	*
DISCHG	Total annual number of patients discharged or admitted	LGDISC	1,2
DISCH2	DISCHG squared	LGDIS2	*
MEALS	Total number of meals served in hospital during year (includes patients and other)	LGMEAL	1
MEAL2	MEALS squared	LGMEA2	*
BEDS	Total number of licensed beds in hospital available for patients at all times.	LGBEDS	1,2
STFPYN	Total number of physicians admitting more than 50 patients per year to a hospital		1
CENSUS	The average number of patients hospitalized per day during a year, i.e., the number of occupied beds per day (PTDAYS/365)		1,2
Participation Variables:			
MEMBER	A dummy variable equal to unity if a hospital participated in the MPSI cooperative at any time during the 3 year period between 1972 and 1974		1
PARMBR	A dummy variable equal to unity if a hospital participated in the cooperative for more than three months of any year		1
PARMOS	The number of months per year of participation in the pharmacy service of the cooperative MPSI		1

TABLE 8--Continued.

Variable Name	Definition of Variable	Natural Logarithm of Variable (If Applicable)	Source[1] of Data
PARWTD	PARMOS weighted by the proportion of total drug costs obtained through the cooperative MPSI.		*
Geographic Variables:			
METRO	A dummy variable equal to unity if a hospital is located in Oklahoma City or Tulsa city limits		4
MISEC	The number of road miles between a hospital and its closest secondary care referral hospital		4
MITERT	The number of road miles between a hospital and its tertiary care referral medical center located either in Oklahoma City or Tulsa		4
POPDEN	The population density of county in which the hospital is located as given by the 1970 county census data.		5
Prices:			
ACLHOS	Average annual total hospital labor cost per full time equivalent employee (WCHOSP/FTEHOS)	LGLHOS	*
ACLPHA	Average annual labor cost of pharmacy services per full time equivalent employee (WCPHAR/FTEPHA)	LGLPHA	*
ACLDIE	Average annual labor cost of dietary department per full time equivalent employee (WCDIET/FTEDIE)	LGLDIE	*

TABLE 8--Continued.

Variable Name	Definition of Variable	Natural Logarithm of Variable (If Applicable)	Source[1] of Data
ACLMED	Average annual labor cost of medical records department per full time equivalent employee (WCMEDR/FTEMED)	LGLMED	*
MPSIPR	Drug price index calculated from sample of hospitals reporting drug unit cost and volume data	LGMPSI	*
Interaction Variables:			
PT2AC	Equals the product of PTDAY2 and PARMOS		*
PT2MOS	Equals the product of LGPTD2 and PARMOS		*
PTAC	Equals the product of PTDAYS and PARMOS		*
PTMOS	Equals the product of LOGPTD and PARMOS		*
Scope of Services Variables:			
FACIL	The number of facilities and services listed in the AHA Guide Issue		1,2
F1	A dummy variable equal to unity for hospitals reporting between 2 and 4 facilities and services		*
F2	A dummy variable equal to unity for hospitals reporting between 5 and 8 facilities and services		*
F3	A dummy variable equal to unity for hospitals reporting 10 or 11 facilities and services		*

TABLE 8--Continued.

Variable Name	Definition of Variable	Natural Logarithm of Variable (If Applicable)	Source[1] of Data
F4	A dummy variable equal to unity for hospitals reporting between 12 and 18 facilities and services		*
F5	A dummy variable equal to unity for hospitals reporting between 21 and 32 facilities and services		*
Other Variables:			
CONTRL	A dummy variable equal to unity if a hospital is owned by an entity of county, municipal or state government		1,2
ACCRED	A dummy variable equal to unity if a hospital was accredited by the Joint Commission on Accreditation of Hospitals		1,2
ALOS	The average length of stay per patient in days (PTDAYS/DISCHG)		*,2
OCRATE	The ratio of occupied beds to available beds per year; i.e., the average number of available beds occupied during the year expressed as a proportion (CENSUS/BEDS=PTDAYS/BEDSx365)		*,2
PDXPYN	The average annual number of patient days per admitting physician (PTDAYS/STFPYN)		*
TIMEYR	A trend variable set equal to unity for observations in 1972, equal to 2 for 1973, and equal to 3 for 1974		*

TABLE 8--Continued.

Variable Name	Definition of Variable	Natural Logarithm of Variable (If Applicable	Source[1] of Data
FREEZE	A dummy variable set equal to unity in 1973 and zero for 1972 and 1974		*
INFLA	A dummy variable set equal to unity in 1974 and zero in 1972 and 1973		*
REGPHA	A dummy variable equal to unity if a full time registered pharmacist is employed in the hospital		1
APPRVL	A dummy variable equal to unity if hospital is approved for post graduate medical education training, nursing school, or cancer program		2
WCHOSP	Total annual wage costs per hospital, services	LGWCHO	1,2
WCPHAR	Total annual wage costs for pharmacy service	LGWCPH	1
WCDIET	Total annual wage costs for dietary service	LGWCDI	1
WCMEDR	Total annual wage costs for medical records department	LGWCMR	1
FTEHOS	Total number of full time equivalent hospital employees		1,2
FTEPHA	Total number of full time equivalent employees in pharmacy service		1
FTEDIE	Total number of full time equivalent employees in dietary department		1

TABLE 8--Continued.

Variable Name	Definition of Variable	Natural Logarithm of Variable (If Applicable	Source of Data[1]
FTEMED	Total number of full time equivalent employees in medical records department		1
CDRUGS	Total annual cost of drugs purchased in pharmacy service from all sources	LCDRGS	1
CIVS	Total annual cost of IV's (intravenous products) to hospital from all sources	LGIVS	1
CFOOD	Total annual cost of food in dietary department	LGCFD	1

Sources of Data:

[1]Primary data reported by hospital or by MPSI management during survey conducted in Spring of 1975 by the Center for Economic and Management Research, College of Business Administration, University of Oklahoma, Norman, Oklahoma.

[2]Guide Issue, Volumes 1972, 1973, 1974, 1975, American Hospital Association, Chicago.

[3]Hospital Statistics, Annual Editions 1974-1976, American Hospital Association, Chicago.

[4]Determined from Road Map of Oklahoma.

[5]County Population Estimates, Census Data, 1970, Oklahoma Employment Security Commission.

*Calculated.

TABLE 9

ESTIMATED TOTAL AND AVERAGE COST EQUATIONS AND EXPECTED SIGNS AND ESTIMATED COEFFICIENTS FOR PHARMACY, DIETARY, MEDICAL RECORDS, AND ALL HOSPITAL SERVICES

1 Cost Category	2 Dependent Variable	3 Output	4 Output^2	5 Factor Prices	6 Location	7 Membership	8 Participation	9 Interaction Variables
PHARMACY	LGTCPH	+LOGPTD	-LGPTD2	+LGLPHA +MPSIPR	±MITERT ±MISEC	±MEMBER	-PARMBR -PARMOS -PARWTD	+PTMOS +PT2MOS
	ACPHPD	-PTDAYS	+PTDAY2	+ACLPHA +MPSIPR	±MITERT ±MISEC	±MEMBER	-PARMBR -PARMOS -PARWTD	+PTAC +PT2AC
DIETARY	TCDIET	+LGMEAL	-LGMEA2	+LGLDIE	±MITERT	±MEMBER	-	-
	ACMEAL	-MEALS	+MEAL2	+ACLDIE	±MITERT	±MEMBER	-	-
MEDICAL RECORDS	LGTMR	+LGDISC	-LGDIS2	+LGLMED	±MITERT	±MEMBER	-	-
	ACMEDR	-DISCHG	+DISCH2	+ACLMED	±MITERT	±MEMBER	-	-
ALL HOSPITAL SERVICES	LGTCHO	+LOGPTD	-LGPTD2	+LGLHOS	±MITERT ±METRO ±POPDEN	±MEMBER	-PARMBR -PARMOS -PARWTD	+PTMOS +PT2MOS
	ACHOSP	-PTDAYS -DISCHG	+PTDAYS2 +DISCH2	++ACLHOS	±MITERT ±METRO ±POPDEN	±MEMBER	-PARMBR -PARMOS -PARWTD	+PTAC +PT2AC

TABLE 9--Continued.

1 Cost Cate- gory	2 Depen- dent Variable	10 Owner- ship	11 Time Trend	12 Wage- Price Freeze	13 Scope of Services	14 Qual- ity	15 Physician Avail- ability	16 Utili- zation
PHAR- MACY	LGTCPH	-CONTRL	+TIMEYR	INFLA -FREEZE	+FACIL +ALOS	+REGPHA +ACCRED +APPRVL	±BDXPYN	±OCRATE
	ACPHPD	-CONTRL	+TIMEYR	+INFLA -FREEZE	+FACIL -ALOS	+REGPHA +ACCRED +APPRVL	±BDXPYN	±OCRATE
DIETARY	TCDIET	-CONTRL	+TIMEYR	+INFLA -FREEZE	+FACIL +ALOS	+ACCRED +APPRVL	±BDXPYN	±DCRATE
	ACMEAL	-CONTRL	+TIMEYR	+INFLA -FREEZE	+FACIL -ALOS		+BDXPYN	
MEDICAL RECORDS	LGTCMR	-CONTRL	+TIMEYR	+INFLA	+FACIL +ALOS	+ACCRED +APPRVL	±BDXPYN	±OCRATE
	ACMEDR	-CONTRL	+TIMEYR	+INFLA	+FACIL -ALOS	+ACCRED +APPRVL	±BDXPYN	±OCRATE
ALL HOSPI- TAL	LGTCHO	-CONTRL	+TIMEYR	+INFLA -FREEZE	+FACIL +ALOS	+ACCRED +APPRVL	±BDXPYN	±OCRATE
SER- VICES	ACHOSP	-CONTRL	+TIMEYR	+INFLA -FREEZE	+FACIL -ALOS	+ACCRED +APPRVL	±BDXYN	±OCRATE

ACLHOS, ACLPHA, ACLDIE, ACLMED for the four cost categories, total hospital, pharmacy, dietary and medical records, respectively.

In the pharmacy department, a survey of the prices and usage of 53 drugs completed by 45 hospitals enabled calculation of a drug price index (MPSIPR) which was used as a second factor price variable in the pharmacy service. Price indices were not available in any other cost category. Expected signs for factor prices are all positive reflecting an expected higher total cost for those hospitals paying the higher factor price.

Participation Variables

To establish a baseline for all hospitals, total cost functions were estimated with the variable MEMBER in the pooled samples and by year to determine if those hospitals which eventually gained membership in the cooperative were operating on a different production curve than nonparticipants. For example, there could have been a self selection process of more (less) efficient administrators who sought membership. The variable MEMBER was a dummy variable with value unity if a hospital gained membership at any time between 1972 and 1974 and was zero otherwise.

A second dummy variable, PARMBR, was alternatively included to determine if membership influenced total costs. This variable was set equal to unity if a hospital had been a member for more than three months of a fiscal year and zero otherwise. Analysis of monthly cost and volume data showed that a period of three months usually expired between the date of formal membership and actual utilization of the cooperative services.

A more sensitive measure of the influence of participation was the variable PARMOS, defined as the total number of months of actual utilization by a participant during the year. Thus, PARMOS ranged from a value of zero to 12.

A final variable, PARWTD, was defined as the number of months of participation weighted by the proportion of total service costs obtained from the cooperative during the year. Values of PARWTD ranged from zero to 3.0.

Each participation variable was included separately in the regression equations in an exploratory fashion to determine which variable was most significant.

Interaction Variables

The interaction of linear and second order output variables with participation was estimated by inclusion of the variables PTMOS or PT2MOS defined as the product of LOG (OUTPUT) or LOG (OUTPUT^2) and PARMOS, respectively. Interaction variables would show the joint effect of scale and participation on hospital cost curves. Positive values of the estimated interaction coefficients would reflect diseconomies from participation at larger scales while a negative value would indicate improved efficiency to larger scale hospitals from greater participation.

Qualitative Changes Due to Cooperative

Caution is required in interpretation of the coefficients of the participation variables because of the possible influence which improved quality may have on cost. For example, the cooperative pharmacy service distributes a full inventory of unit dose packaged oral solid drugs, not all of which are available commercially to individual hospitals. The additional expense of repackaging from bulk to unit dose was undertaken by the cooperative for the express purpose of upgrading the drug distribution systems in hospitals by making unit dose distribution feasible. Change to the new distribution system has occurred in some, but not all, of the participating hospitals.

Qualitative Differences among Hospitals

Measurement of quality differences in the care provided by individual hospitals is a question on which no consensus is available. Following the approaches of others, this study included dummy variables for accreditation by the Joint Commission on Hospital Accreditation or by the American Osteopathic Association (ACCRED). Approval for reimbursement by Medicare or Medicaid financial intermediaries was obtained by all hospitals in this study with only two institutions not reporting approval by both authorities.

Hospitals approved for other special services such as cancer, internship or residency programs or medical school affiliation were identified by the dummy variable APPRVL set equal to unity. Hospitals not receiving approval in any one of these services were given the value of zero for this variable. A positive coefficient is expected for quality variables.

Professional Manpower: Quality versus Cost Containment

There is an implicit assumption that the availability of full time professionals in the various services, such as registered record administrators, registered professional dietitians and registered pharmacists, influences the quality of the service provided. The availability of a professional may also be expected to contain costs because of presumed superior coordination of the resource inputs under the professional's control. To account for the effect on cost levels of the presence of a full time registered pharmacist, the dummy variable REGPHA was included with an expected positive coefficient.

Environmental Differences among Hospitals

Certain factors such as geographic location and resource availability are thought to be possible explanations for differences in production costs among hospitals. Proxies for the environmental influences were included in an exploratory attempt to better specify differences between urban and rural hospitals, physician availability, ownership, and utilization. Alternative variables were regressed in all service categories since different services are expected to be affected differently by any single factor. Data limitations did not allow consideration of other factors such as differences in age of the hospitals, recent renovation or expansion, or differences in quality of manpower resources.

Geographic Location

Three variables were included to capture the influence of distance on hospital costs. METRO was a dummy variable equal to zero for all hospitals lying in a community outside of the city limits of Tulsa or Oklahoma City. All hospitals regardless of size within the city limits were assigned a value of unity for this variable. Two variables were defined as the number of road miles between a hospital and the nearest secondary hospital (MISEC) and the nearest tertiary care medical center (MITERT). A fourth alternative measure, POPDEN, was included to consider the influence of differences in population density.

Physician Availability

The lack of physicians may limit the economic viability of the rural as well as the urban hospital. The ratio of the number of licensed beds (BEDS) to the number of admitting physicians (STFPYN) defined as BDXPYN is a proxy for the relative availability of physician resources to the common input (BEDS). Interpretation of the variable is hazardous since physicians are implicitly assumed to be a homogenous resource. This assumption is suspect since physicians in metro areas are primarily specialists whereas physicians in rural communities are predominately general or family practitioners. More importantly, some physicians admit patients to two or more hospitals, especially in the metro areas. However, if the sample of hospitals is stratified, BDXPYN may be a useful proxy for resource constraints on hospital utilization.

Utilization

Differences in utilization among hospitals may occur as short run fluctuations in demand, e.g., the flow of patient admissions over time. In addition, hospital utilization may be planned as has been suggested to explain the relatively lower occupancy rates of rural and smaller institutions compared to the larger metropolitan hospitals. The occupancy rate (OCRATE) which is defined as the ratio of occupied beds to total available beds is included in the estimated functions.

A related measure of utilization is the number of beds per admitting physician (BDXPYN). In the larger and metropolitan hospitals, this measure may not be reliable because of physicians admitting to more than one hospital; however, in rural hospitals the probable error may not preclude this variable from consideration.

Ownership

Ownership has been suggested as a significant causal factor of hospital efficiency and other sources of hospital cost variation. (Klarman, 1965) While proprietary hospitals are not included in this study, both municipally owned and county government hospitals are present along with voluntary nongovernmentally owned institutions. A source of cost variation which could be expected between the governmental and nongovernmental hospitals is the opportunity afforded the government hospitals to purchase on the state negotiated contract prices. State government hospitals are required by law to purchase on these contracts, whereas municipal and county hospitals are eligible but are not required to do so.

The dummy variable CONTRL was defined as unity for all hospitals owned by city, county or state government. All nongovernment not-for-profit hospitals were assigned values of zero. No federal government nor for-profit hospitals were included in the study.

Time Trend and Wage-Price Controls

The variable TIMEYR accounted for the effects of trends in costs during the three year period. Values of TIMEYR were unity in 1972, two in 1973 and three in 1974. During the three year period the federal government imposed wage and price controls on the hospital industry. As a result cost increases to hospitals for labor and other expenses were very small in 1973 following 1972. To account for the effect of the wage-price freeze which ended in 1973, the dummy variable FREEZE set equal to unity in 1973 and zero other times was included in estimated equations.

Data

Data were obtained for 59 Oklahoma and 9 Kansas hospitals located in the trade area of the hospital shared services cooperative, M.P.S.I. Primary data were reported during the spring of 1975 by 38 of the 66 hospitals located within a 100 mile radius of the M.P.S.I. home office in Bartlesville, Oklahoma. (CEMR, 1976) At the time of the survey, 27 of the 38 hospitals were members of M.P.S.I. participating in one or more of the cooperative's services. In each of the 38 hospitals structured interviews were held with hospital administrators, pharmacists, purchasing agents, nurses and other staff personnel who were at that time involved or who could conceivably in the future become involved with cooperative arrangements. Administrators were requested to provide operating statistics for seven hospital services and functions for the three fiscal periods of 1972 through 1974.[1] Responses provided a minimum of 20 (1972) and a maximum of 25 (1974) complete hospital data sets for the pharmacy, dietary, and medical records services and the total hospital

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[1]Interview guides and operating statistic data sheets for the seven hospital services are reproduced in Appendices A and B, CEMR, 1976.

expenses cost category. Responses to the other three services were insufficient in number or in detail to be included in the cost study.

During the course of the hospital survey it was learned that the cooperative's trade area extended considerably beyond the distance of 100 miles including all 121 hospitals in the state of Oklahoma. In 1975 the cooperative was establishing an extended market throughout the state in pharmacy and microfilming services. Sales of unit dose packaged drugs to 36 rural hospitals participating in three other newly formed hospital cooperatives located in Ardmore, Lawton and Enid represented about 15 percent of total MPSI drug sales in June 1975. Furthermore, a contract with the Central Oklahoma Hospital Shared Services, Inc., representing 32 Oklahoma City area hospitals, doubled the MPSI scale of production in microfilming of medical records. Thirty of these rural and urban Oklahoma hospitals, responding to mail surveys, provided limited data on costs and usage of drug items and operating statistics for the total hospital expenses cost category. Supplementing the primary data sources were published statistics by the American Hospital Association (Hospital Statistics and Guide Issues) which report annual hospital operating statistics. The mailed surveys and the secondary data source enabled completion of 68 hospital data sets for the total expenses cost category for the three year period.

The number of observations for each service and cost category, which was determined by the hospital response rates, is summarized in Table 10 for each year and for the pooled samples of two and three years of data. In some cases data were missing for one or two years. In addition are shown the two purchasing functions of drugs and intravenous products for which separate regressions were run.

Drug cost and usage data were obtained from 45 hospitals for a sample of 53 high usage or high dollar volume drugs carried in inventory by MPSI. Hospitals were asked to report cost documented by invoices prevailing prior to membership in MPSI or for nonmembers at the date of the survey. Actual charges and usage for each line item drug purchased from MPSI by member hospitals were obtained from records of MPSI. An annual drug price index was calculated for each hospital for the pre- and post-membership periods as a proxy for the price of the input drugs in the pharmacy service. Complete data sets, however, were limited to 15 hospitals and a maximum of 44 observations in the pooled sample.

The sample of 68 hospitals considered in this study represents less than one percent of the 5,977 community hospitals in the nation in 1974. Furthermore, the samples were not randomly selected since only reporting hospitals are included. Therefore, the results of the study should not be generalized to the entire population of all community hospitals.

TABLE 10

NUMBER OF OBSERVATIONS BY SERVICE, BY YEAR AND POOLED SAMPLES, 1972-1974

Service	Number of Observations by Years					
	1972	1973	1974	1972-1973	1973-1974	1972-1974
Total Expenses All Hospital Services	66	67	67	133	134	200
Dietary Services	21	21	22	42	43	64
Medical Records Service	23	23	24	46	47	70
Pharmacy Service	23	24	25	47	49	72
Cost of Drugs Function	23	24	25	47	49	72
Cost of Intravenous Products Function	20	21	22	41	43	63
Drug Price Index	14	15	15	29	30	44

However, the aggregate analysis of 68 hospitals and the selected services samples of a minimum of 20 hospitals represent 56 and 17 percent respectively of the 121 community hospitals in Oklahoma. The large sample size relative to the total population of hospitals may enable tentative extrapolations of the results from this study to groups of hospitals located in other parts of Oklahoma and Kansas or to other regions of similar hospital characteristics.

Classification of Hospitals

Following the general outline of Berry and Carr (1973) hospitals were classified into institutions providing primary, secondary and tertiary patient care according to the number and type of facilities and services provided. Tertiary care medical centers were defined as those institutions offering intern and post graduate training programs and providing one or more of the more complex medical services such as neurological surgery, burn care center, renal dialysis and others. This class included the eight largest institutions in Oklahoma all of which are located in Oklahoma City and Tulsa metro areas.

The distinction between primary and secondary care institutions was more arbitrary. Secondary care institutions were defined as those providing services corresponding to Berry and Carr's "complexity expanding services" such as intensive care unit, radioisotope therapy, therapeutic X-ray, radium and cobalt therapy, electroencephalography, physical therapy and dental facilities. Following this general approach 18 secondary care institutions were identified. Two essential requirements for classification as a secondary facility were the reporting of at least 12 facilities and the presence of a minimum of 14 physicians each admitting more than 50 patients per year. The latter requirement represented a group of physicians sufficiently large to include specialists in internal medicine, cardiology, obstetrics and gynecology, radiology, pediatrics and pathology. Table 11 presents the mean values and ranges of selected hospital characteristics for each class.

The third category, called primary care institutions, includes the remaining 42 hospitals. Berry and Carr distinguished two groups within this category on the basis of facilities and services offered: those providing basic services, and those providing quality enhancing services. Further division of the primary care class into three subclasses offered the benefit of further reducing the multicollinearity problem. Hospital characteristics of each of these subclasses are also presented in Table 11.

The subclass P1 reflects the smallest size hospitals with mean number of acute beds of 37 and mean staff of 3.9 physicians. Patient load averaged 7,428 patient days, ranging between 3,285 and 11,686 patient days while the number of annual discharges, ranging between 353 and 1,853, averaged 1,131 during the three year period. Reading up

TABLE 11

HOSPITAL CHARACTERISTICS BY CLASS: MEAN VALUES AND RANGES, POOLED DATA, 1972-1974

Hospital Class	Number of Hospitals	Number of Observ	Number Licensed Acute Beds (BEDS)		Number Patient Days (PTDAYS)		Number Discharges (Admissions) (DISCHG)		Ave. Length Pat. Stay in Days (ALDS)	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range
ALL HOSPITALS	68	200	130	19-625	34,424	3,285-200,750	5,73	352-26,910	6.38	4.50-10.15
TERTIARY CARE	8	23	433	181-625	124,692	48,910-200,750	16,945	7,347-26,910	7.11	5.72-8.30
SECONDARY CARE	18	51	180	76-293	49,814	17,532-100,378	7,878	3,486-14,868	6.31	5.03-7.69
PRIMARY CARE	42	126	54	19-107	11,717	3,285-30,658	1,131	352-5,487	6.26	4.50-10.15
P3	9	27	77	46-107	16,586	8,965-24,608	2,791	1,665-4,175	5.93	4.50-7.1
P2	19	53	52	26-108	12,135	3,656-30,658	2,039	672-5,483	6.00	4.84-7.43
P1	14	42	37	19-60	7,428	3,285-11,624	1,131	352-1,853	6.82	5.06-10.15

TABLE 11--Continued.

Hospital Class	Respective Dummy Variable for Facilities	Number of Facilities Available (FACIL)		Number of Staff Physicians (STFPYN)		Occupancy Rate (OCRATE)		Number of Hospital Employees (FTEHOS)	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
ALL HOSPITALS	NA	10.7	2-32	43.7	1-275	.656	.313-.92	299	23-1667
TERTIARY CARE	F5	26.5	21-32	222.0	124-275	.780	.628-.886	415	153-786
SECONDARY CARE	F4	14.7	12-18	54.8	14-200	.747	.590-.920	130	42-260
PRIMARY CARE	NA	6.3	2-11	6.7	1-14	.597	.313-.88	93	23-218
P3	F3	10.7	10-11	8.4	2-14	.588	.418-.734	140	65-218
P2	F2	6.5	5-8	6.1	2-11	.616	.313-.88	93	31-260
P1	F1	3.1	2-4	3.9	1-10	.587	.33-.86	55	23-88

TABLE 11--Continued.

Hospital Class	Percent of Hospitals which Are:				
	Accredited (ACCRED)	Approved for Post-Grad. Education (APPRVL)	Owned by City/County Government (CONTRL)	Included in Each Sample %	Located in OKC or Tulsa Metro Areas (METRO)
ALL HOSPITALS	.765	0.160	.52	100.0	.190
TERTIARY CARE	1.000	1.00	.09	11.5	1.00
SECONDARY CARE	1.000	0.176	.47	25.5	.294
PRIMARY CARE	.627	0.0	.61	63.0	0.0
P3	1.000	0.0	.55	13.5	0.0
P2	.680	0.0	.74	25.0	0.0
P1	.357	0.0	.50	21.0	0.0

TABLE 11--Continued.

Hospital Class	Average Hospital Cost per Patient Day (ACHPTD) ($)		Average Hospital Cost per Patient Stay (ACHSTA) ($)		Total Hospital Costs Per Year ($000's) (TCHOSP)		Average Hospital Wage Rate per Year (ACLHOS)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
ALL HOSPITALS	84.34	49.94- -156.80	538.61	282- 1,197	3.377	.222- 22.55	5,577	3,012- 8,377
TERTIARY CARE	116.63	89.14- 156.80	842.25	602- 1,197	14.371	5.385- 22.550	6,528	4,712- 8,377
SECONDARY CARE	90.28	73.06- 119.90	566.46	407- 724	4.549	1.421- 10.108	5,793	4,087- 7,017
PRIMARY CARE	76.04	49.94- 125.14	471.92	282- 784	.896	.222- 2.450	5,317	3,012- 7,613
P3	83.02	51.51- 125.14	489.27	330- 757	1.382	.617- 2.450	5,536	3,898- 7,613
P2	75.92	49.94- 137.26	453.66	282- 727	.902	.297- 2.341	5,262	4,437- 6,421
P1	69.48	52.07- 105.97	472.48	306- 784	.513	.222- .856	5,135	3,012- 6,807

Table 11, one notes the increasing scale of operations from class to class to the tertiary care which shows mean values of 433 beds, 16,945 discharges, 222 staff physicians, 26.5 facilities and 1,177 employees.

Pooling of Cross Sectional and Time Series Data

Cross sectional data are sometimes subject to factors peculiar to the particular year or to random shocks which affect individual or groups of observations. Examples include acquisition of new technology, remodeling of facilities or the opening of a new wing, any of which could affect output and expenses of the hospital.

The availability of three consecutive years of data provides repeat observations which would tend to deemphasize the importance of these random influences. The data may be treated by averaging the time series observations or by pooling all observations into a combined cross-sectional and time series sample. Both methods are equivalent to taking repeat observations on the same independent and dependent variables. Pooling the data is the approach used in this study primarily because of the increased number of degrees of freedom obtained.

Pooling is also preferred to averaging for another reason. Averaging of time series data to a single cross sectional sample would tend to hide structural shifts which could have occurred during the three year period. Averaging of data also would require deflating by an appropriate weighting factor for which reliable data are unavailable. Pooling of all data, on the other hand, would tend to capture any shifts in structure in unexplained variation, thereby reducing the significance of the estimated relationships. Furthermore, known shocks to the hospital industry such as the wage and price freeze affecting the upward trend of cost structure during 1972 and 1973 can be accounted for in the pooled sample directly by inclusion of additional explanatory variables.

Homogeneity of Output Assumptions

The tendency for the scope and complexity of hospital output to increase with the size of the hospital poses a major difficulty in analyzing hospital costs. This study adjusted output proxies for heterogeneity by each of the following procedures:

1. Assuming all hospital output homogeneous.
2. Inclusion of output adjustment variables in estimating equations:
    a. the number of facilities and services available at each hospital (FACIL).
    b. inclusion of the average length of stay (ALOS).
3. Stratification of hospitals by class into subsamples.
4. Inclusion of dummy variables for each respective class in the total sample (P1, P2, P3, P4).

Results presented below are based on the best fit and most empirically appropriate equations selected from those estimated for each of above alternatives. Choice of the best equations considered the influence of multicollinearity of independent variables, theoretical arguments for inclusion of the variables, stability and level of statistical significance of estimated coefficients, and the range of scale and number of observations included in each sample.

Multicollinearity among Independent Variables

Collinearity among independent variables has been a continuing difficulty facing all hospital cost studies especially those attempting to adjust for product homogeneity by adding proxies to account for differences in product scope and complexity. In addition, nonlinear specifications which include two or more measures of the same variable, such as output in this study, encounter high coefficients of correlation. Collinearity between output variables and environmental proxies may also present difficulties. Table 12 presents the correlation matrix of output and adjustment variables, and environmental proxies for geographic location, ownership, quality, physician availability and utilization for the pooled sample of 200 observations on 68 hospitals between 1972 and 1974.

Inspection of the top row, for example, shows the simple correlation coefficient between the output variable LOGPTD and ten independent variables. The variable for

TABLE 12

CORRELATION MATRIX

N=100	OUTPUT AND ENVIRONMENTAL VARIABLES									
	LOCATION				OWNER-SHIP	QUALITY		PHYSICIAN AVAILABILITY		UTILIZA-TION
	METRO	MISEC	MITERT	POPDEN	CONTRL	ACCRED	APPRVL	STFPYN	PDXPYN	OCRATE
LOGPTD	.717	-.583	-.482	.642	-.285	.472	.655	.794	-.478	.651
FACIL	.699	-.479	-.474	.579	-.251	.440	.730	.835	-.513	.464
ALOS	.274	-.308	-.236	.304	-.263	-.063	.372	.380	.000	.130
METRO	1.0	-.510	-.659	.829	-.372	.368	.693	.867	-.467	.468
MISEC		1.0	.614	-.577	.209	-.050	-.479	-.538	.458	-.418
MITERT			1.0	-.734	.251	-.061	-.444	-.598	.566	-.449
POPDEN				1.0	-.350	-.220	.618	.778	-.520	.483
CONTRL					1.0	-.066	-.313	-.360	.147	-.264
ACCRED						1.0	.241	-.506	-.250	.650
APPRVL							1.0	.842	-.398	.358
STFPYN								1.0	-.506	.450
PDXPYN									1.0	-.255
OCRATE										1.0

TABLE 13

CORRELATION COEFFICIENTS, FACIL COMPARED TO SELECTED INDEPENDENT VARIABLES BY STRATIFIED SAMPLE (HOSPITAL CLASS)

Hospital Class (Sample)	No. of Obser-vations	Independent Variables				
		LOGPTD	PTDAYS	MITERT	ALOS	OCRATE
All Hospitals	200	.89	.87	-.48	.20	.47
Tertiary Care	23	.66	.57	NA	.67	.07
Secondary Care	51	.09	.15	.36	.06	-.11
Primary Care	126	.62	.60	.09	-.39	.03
P3	27	-.06	-.11	.13	.21	.18
P2	53	.28	.34	.01	-.06	.11
P1	42	.58	.57	.31	-.38	.08

Analysis of Aggregate Hospital Output

The objectives of the analysis of costs for all hospital services are to estimate the degree of returns to scale and shed light on the assumptions made in other parts of this study such as the degree of homogeneity of output proxies and the appropriateness of pooling time series and cross sectional data. This section presents the results of the aggregate hospital cost regressions.

Ordinary least square regressions were run for linear and quadratic specifications of the estimating equations using the number of patient days and the number of discharges alternatively as measures of output. The results presented employ the number of patient days as output proxy, although approximately the same results were obtained using the number of discharges.

The choice between the appropriateness of linear and quadratic specifications was usually not difficult, the linear form being the preferred choice based on stability and statistical significance of estimated coefficients and changes in the value of the standard errors of the regression. Further, linear forms did not include the multicollinearity problems present in the quadratic equations.

Estimated Returns to Scale: Pooled Sample of Aggregate Hospital Services

Table 14 presents the estimated linear and quadratic equations for total costs (LGTCHO) and average costs per patient day (ACHPTD) and per patient stay (ACHSTA), the estimated coefficients, t and F scores, and standard errors for the pooled sample of 200 observations on 68 hospitals. The equations shown include statistically significant variables for geographic location (MITERT), average length of stay (ALOS), the price of labor (ACLHOS or LGLHOS), time trend (TIMEYR), adjustment for product homogeneity by including dummy variables for four classes of hospitals (P1, P2, P3, P4) and capacity utilization measured by the occupancy rate (OCRATE).

The results of the total cost regressions indicate that hospitals experience diseconomies of scale over most of the range of scale from the smallest to the largest hospitals. Output coefficients for the linear and quadratic total cost equations were positive. In the linear equation, the output coefficient (b_1) shown in Table 14 was 1.0834 indicating moderate diseconomies in production with substantial differentials in the levels of cost for each class of hospital (P1, P2, P3, P4).

In the quadratic form of the total cost equation the coefficient b_2 of the squared output variable is not significant with a t statistic of 0.8. Although the magnitude of linear output coefficient of 0.9156 is consistent with scale economies, the standard error of the estimate is too large to conclude that b_1 differs from unity. Furthermore,

TABLE 14

ESTIMATED EQUATIONS FOR TOTAL AND AVERAGE HOSPITAL COSTS
ALL SERVICES, 1972-1974, N=200
(t-Statistics in Parentheses)

Dependent Variable	Constant C	OUTPUT b_1	$(\text{OUTPUT})^2$ b_2	TIMEYR	MITERT	ALOS	ACLHOS LGLHOS
LGTCHO	1.760 (2.6)	1.0834 (49.5)	-	.0846 (7.2)	-.00189 (-7.2)	-.0349 (-3.0)	.3081 (3.9)
LGTCHO	2.628 (2.0)	.9156 (4.1)	.00836 (0.8)	.0844 (7.3)	-.00186 (-7.0)	-.0365 (-3.1)	.3030 (3.8)
ACHPTD	117.51 (10.5)	$.760\text{x}10^{-4}$ (2.0)	-	7.23 (6.8)	-.1583 (-6.7)	-2.849 (-2.7)	.00537 (4.1)
ACHPTD	115.20 (10.5)	$.4591\text{x}10^{-3}$ (3.9)	$-.1946\text{x}10^{-8}$ (-3.5)	7.37 (7.2)	-.1545 (-6.7)	-3.23 (-3.2)	.00502 (4.0)
ACHSTA	239.71 (3.4)	$.7324\text{x}10^{-3}$ (3.0)	-	47.23 (7.1)	-.8865 (-5.9)	61.83 (9.3)	.0319 (3.9)
ACHSTA	223.04 (3.3)	.0035 (4.8)	$-.1407\text{x}10^{-7}$ (-4.0)	48.29 (7.6)	-.8585 (-6.0)	59.04 (9.2)	.02942 (3.7)

TABLE 14--Continued.

Dependent Variable	P1	P2	P3	P4	OCRATE	R^2	$F_{(v,u)}$	Standard Error
LGTCHO	-.2354 (-3.9)	-.1671 (-3.3)	-.1742 (-3.4)	-.0792 (-2.3)	-.7922 (-8.8)	.9887	(10,189) 1647	.1277
LGTCHO	-.2273 (-3.8)	-.1554 (-2.9)	-.1569 (-2.8)	-.0662 (-1.7)	-.7824 (-8.6)	.9887	(11,188) 1494	.1278
ACHPTD	-29.06 (-5.9)	-20.44 (-4.5)	-19.88 (-4.2)	-9.60 (-2.7)	-53.24 (-7.2)	.7063	(10,189) 45	11.47
ACHPTD	-21.98 (-4.2)	-15.45 (-3.4)	-16.06 (-3.4)	-12.44 (-3.5)	-59.49 (-8.0)	.7240	(11,188) 45	11.14
ACHSTA	-200.30 (-6.5)	-143.68 (-4.7)	-142.44 (-3.7)	-82.32 (-3.7)	-325.71 (-8.0)	.7988	(10,189) 75	72.43
ACHSTA	-149.11 (-4.6)	-107.55 (-3.7)	-114.82 (-3.8)	-102.85 (-4.7)	-370.93 (-8.0)	.8147	(11,188) 75	69.70

coefficients estimated from the quadratic forms are unstable in regressions of cross sectional data.

The average cost equations (ACHPTD and ACHSTA) yielded somewhat contradictory results. The linear output coefficients (b_1) estimated in both the linear and quadratic forms were positive indicating diseconomies of scale. In the quadratic form, however, the coefficient of the squared output variable, b_2, was negative indicating an inverted U-shape of the average cost curve. In the quadratic regressions average costs are increasing up to output levels of between 118,000 and 124,000 patient days which corresponds to a daily census of 323 to 341 patients in a hospital of 430 to 450 beds, assuming an occupancy rate of 75 percent. The tendency for average cost curves to flatten out at the larger production scales is also indicated by results from regressions run for stratified samples of hospital classes.

Results of Stratified Samples of Class

Closer examination of the cost-scale relationship was achieved by estimating equations for each of the seven stratified samples corresponding to the primary, secondary and tertiary care classes and each of the three subclasses of primary care hospitals (P1, P2, P3). Results of the estimated total and average cost equations which are presented in Tables 15 and 16 indicate that diseconomies obtain in all classes of hospitals with two exceptions. In the smallest class, P1, increasing returns to scale are indicated

TABLE 15

SUMMARY OF REGRESSION EQUATIONS
NATURAL LOGS OF TOTAL HOSPITAL COSTS (LGTCHO) BY CLASS

Hospital Class	Number of Observations	Constant C	Independent Variables					
			b_1 LOGPTD	d_1 LGLHOS	MITERT	BDXPYN	OCRATE	ALOS
ALL HOSPITALS	200	1.7596 (2.6)[1]	1.0837 (49.5)	.3081 (3.9)	-.1887-02 (7.2)	Omitted	-.7922 (-8.8)	-.3491 (-3.0)
TERTIARY CARE	23	3.75 (4.8)	1.0287 (34.0)	.1662 (1.9)	N.A.[2]	Omitted	-1.320 (-6.2)	N.S.
SECONDARY CARE	51	4.115 (12.2)	1.0502 (31.0)	Omitted	-.1458-02 (-3.9)	.8881-04 (3.0)	Omitted	-.5470 (-3.2)
PRIMARY CARE	126	1.529 (1.7)	1.0752 (31.8)	.3108 (3.0)	-.0020 (-6.1)	Omitted	-.9030 (-8.2)	-.0177 (-1.2)
P3	27	-1.162 (-1.0)	1.2647 (16.9)	.4872 (3.3)	-.3461-02 (-6.4)	Omitted	-.8448 (2.6)	-.9921 (-3.0)
P2	53	3.9661 (7.8)	1.1374 (18.4)	Omitted	-.1918-02 (-4.1)	Omitted	-1.1315 (-5.3)	-.4344 (-1.3)
P1	42	5.24 (10.1)	.8915 (13.9)	Omitted	.00177 (1.6)	$-.521\times10^{-7}$ (-2.4)	-.379 (-2.3)	Omitted

[1]t-statistics are shown in parentheses.

[2]Not applicable.

TABLE 15--Continued.

Hospital Class	F1	F2	F3	F4	TIMEYR	R^2	$F_{(u,v)}$	Standard Error
ALL HOSPITALS	-.23541 (-3.9)	-.16705 (-3.3)	-.17424 (-3.4)	-.07915 (-2.3)	.0846 (7.2)	.9887	(10,189) 1,647.3	.1277
TERTIARY CARE	NA	NA	NA	NA	.1208 (7.9)	.9883	(4,18) 379	.0605
SECONDARY CARE	NA	NA	NA	NA	.0780 (5.8)	.9753	(5,45) 356	.0773
PRIMARY CARE	Omitted	.82625 (2.4)	.8361 (1.8)	NA	.0852 (5.4)	.9456	(8,117) 254	.1375
P3	NA	NA	NA	NA	.0758 (3.2)	.9553	(6,20) 71.2	.0956
P2	NA	NA	NA	NA	.0950 (3.4)	.9120	(5,47) 97.4	.1598
P1	NA	NA	NA	NA	.0899 (4.4)	.9133	(5,36) 75.8	.1087

NA--not applicable

TABLE 16

SUMMARY OF REGRESSION EQUATIONS
AVERAGE COST PER PATIENT DAY (ACHPTD) BY CLASS

Hospital Class	Number of Obser- vations	Con- stant C	Independent Variables					
			a_1 PTDAYS	ACLHOS	MITERT	BDXPYN	OCRATE	ALOS
ALL HOSPITALS	200	117.51[1] (10.5)[1]	.7600-04 (2.0)	.5372-02 (4.1)	-.1583 (-6.7)	omitted	-53.24 (-7.2)	-2.849 (-2.7)
TERTIARY CARE	23	181.35 (6.8)	.1976-04 (0.5)	.3263-02 (1.7)	NA	omitted	-150.00 (-4.9)	NS
SECONDARY CARE	51	99.08 (8.9)	.4788-04 (0.8)	omitted	-.1498 (-4.4)	.8492-02 (3.1)	omitted	-4.46 (-2.9)
PRIMARY CARE	126	91.81 (7.4)	.51439-03 (2.2)	.4908-02 (3.0)	-.17525 (-6.2)	omitted	-19.16 (-7.6)	-1.763 (-1.5)
P3	27	108.21 (4.3)	.12317-02 (3.1)	.5451-02 (3.8)	-.2660 (-5.7)	omitted	-78.72 (-2.8)	-6.546 (-2.3)
P2	53	140.32 (6.9)	.7751-03 (1.9)	omitted	-.1818 (-4.4)	omitted	-82.40 (-4.8)	-3.72 (-1.3)
P1	42	82.54 (8.9)	-.00130 (-1.8)	omitted	.136 (1.6)	-.00355 (-2.3)	-27.78 (-2.3)	omitted

TABLE 16--Continued.

Hospital Class	F1	F2	F3	F4	TIMEYR	R^2	$F_{(u,v)}$	Standard Error
ALL HOSPITALS	-29.06 (-5.9)	-20.44 (-4.5)	-19.88 (-4.2)	-9.5970 (-2.7)	7.23 (6.9)	.7063	(10,189) 45.4	11.47
TERTIARY CARE	NA	NA	NA	NA	14.29 (6.8)	.8148	(4,18) 19.8	8.34
SECONDARY CARE	NA	NA	NA	NA	7.35 (5.9)	.6641	(5,45) 17.8	7.19
PRIMARY CARE	omitted	7.045 (2.5)	6.43 (1.7)	NA	6.656 (5.1)	.5826	(8,117) 20.4	11.40
P3	NA	NA	NA	NA	6.278 (3.1)	.8316	(6,20) 16.5	8.16
P2	NA	NA	NA	NA	7.645 (3.2)	.5456	(5,47) 11.3	13.64
P1	NA	NA	NA	NA	6.28 (4.1)	.5415	(5,36) 8.5	8.18

by the estimated coefficients in regressions of both average cost (a_1=.0013, t=1.8) and total costs (b_1=0.8915, t=13.9).

Apparently, an increase in scale for the very small hospitals, which averaged 37 beds within the P1 class, yields economies of scale. Further expansion of the number of services offered, which would shift the hospital into the larger P2 and P3 classes, would bring about higher levels of cost which appear as diseconomies of "scale" as the hospital's product mix and scale of production expand. The positive slope of the average cost curves probably results in part from the inability to adequately account for the increased scope of product mix included within the patient days measure of output.

In the tertiary care class, constant returns to scale are indicated by the low t score of a_1 in the average cost regression and by the magnitude of b_1 in the total cost regression. The small sample of 23 observations on 8 hospitals ranging in output from 49,000 to 200,000 patient days and in scope from 21 to 32 services renders conclusions about cost-output behavior for tertiary care institutions at best tentative.

Grouping the three primary care sub-classes into one sample enabled separate examination of hospitals whose output ranged from 3,000 to 25,000 patient days, which provided between two and 11 services and which had between 19 and 107 beds. This sample includes 126 observations from 44 hospitals.

The coefficient of output (b_1) in the total cost equation shown in Table 15 was 1.0752 (t=31.8) indicating diseconomies of scale over the range of output. Coefficients of the dummy variables for facilities, P2 and P3, were very close in magnitude indicating that these two classes produce at cost levels substantially above the smallest class, P1, but not substantially different from each other. Similar conclusions result from the average cost regression shown in Table 16.

Results of Other Independent Variables

Independent variables included in the specification of the equations which were statistically significant are discussed below. With the exception of the product mix adjustment variable, P1, P2, P3 and P4, and the occupancy rate, these independent variables did not influence the degree of estimated returns to scale.

Price of Labor

Since the total cost equation is the reduced form of the Cobb-Douglass production function, the output elasticity of labor input (α_1) is determined by estimating the coefficient (d_1) of the price of labor (LGLHOS) under the assumptions of cost minimizing behavior and exogeneity of output and of factor prices. From equation (3), the output elasticity of labor is calculated such that

$$\alpha_1 = d_1 r = \frac{d_1}{b_1} .$$

Estimated coefficients of the price of labor (LGLHOS) varied depending on the hospital classes included in the sample. For example, in the hospital sample of 200 observations the estimated coefficient (d_1) shown in Table 15 was .3081. The associated output elasticity was calculated at 0.284. Very similar results were found in the primary care sample of 126 observations which resulted in a value of d_1 equal to 0.3108 and an output elasticity of 0.289. In tertiary care hospitals the estimated coefficient d_1 value of .1662 corresponds to an elasticity of 0.162 while in the P3 class output elasticity of 0.385 was found. In the other classes estimated coefficients of the labor price variable were excluded because of low t scores.

Inspection of the results indicate that the labor output elasticity of .162 in tertiary care class hospitals is substantially lower than the elasticity of .284 estimated for all hospitals. These estimates suggest that the larger hospitals employ relatively greater proportions of labor inputs in production. In part this may be explained by the broader product mix provided by tertiary care hospitals which may include more labor intensive services such as intensive care units requiring considerably greater amounts of labor input per day of hospital care.

The number of full time equivalent hospital employees ranged from a low of 2.7 employees per hospitalized patient in the smallest hospital class, P1, to 3.40 in the tertiary care hospitals. Furthermore, the average annual price of labor ranged from $5,327 for primary care hospitals to $5,764 for secondary care and $8,152 for tertiary care hospitals during the three year period 1972 through 1974.

Geographic Location

The number of miles from the nearest tertiary care medical center (MITERT) is a statistically significant variable in all of the aggregate hospital regressions. Estimates from the all hospital sample of 200 observations indicate that average cost per patient day declines by an average of 15.8 cents per mile as the hospital distance from the tertiary care facility increases. A distance of 44 miles, for example, is associated with a decline in average cost per patient day of 8.2 percent. Equal or larger negative magnitudes of the MITERT coefficient are estimated in the class samples with the exception of the smallest class P1 which shows an increase in average cost per patient day of 13.6 cents per mile.

A chief reason for the negative relationship between cost levels and geographic location is the lower average cost of labor in the more remote areas. The largest absolute value of the simple correlation coefficient between MITERT and the price of labor (-0.33) occurred in the all hospital sample.

Cost Increases over Time

The average annual increase in cost over the three year period is shown by the estimated coefficients for the variable TIMEYR in Tables 15 and 16. Variation in cost increases among hospital classes range from a low of 7.58 percent in class P3 to a high of 12.08 percent in the tertiary hospital class.

A comparison of cross sectional data, however, shows that a major cost increase occurred between 1973 and 1974 with substantially lower increases occurring during the period of the wage-price freeze of 1972 and 1973. For example, in Table 17, which shows 64 hospitals reporting data for all three years, average cost per patient day (ACHPTD) increased from $76.14 in 1972 to $82.21 in 1973, an increase of 8.00 percent, and jumped 13.38 percent more to $93.21 in 1974. Regressions on pooled data for the two year periods 1972-1973 and 1973-1974 yielded insignificant coefficients of the time variable in the former period and coefficients significant at .05 level of confidence or above in the later period for all cost categories.

Inclusion of the variable FREEZE in pooled samples to account for the effect in 1972 and 1973 of the wage-price freeze yielded a consistently negative sign as expected although the level of statistical significance was never better than .10 in contrast to the trend, TIMEYR, which was almost always significant at the .05 level of confidence or above.

TABLE 17

SELECTED HOSPITAL COST VARIABLES AND PERCENT CHANGES, 1972-1974, 64 HOSPITALS REPORTING

Time	No. of Obser-vations	Variables						
		ACHSTA	ACHPTD	TCHOSP ($000,000)	ACLHOS	FTEHOS	PTDAYS	DISCHG
1972	64	$496.38	$76.14	2.989	$5,393	286	33,730	5,015
1973	64	521.45	82.21	3.244	5,443	295	34,050	5,154
1974	64	581.05	93.21	3.819	5,857	318	35,531	5,419
Percent Increases:								
1972 to 1973		5.05%	8.00%	8.53%	0.93%	3.15%	0.95%	2.77%
1973 to 1974		11.43%	13.38%	17.73%	7.61%	7.80%	4.35%	5.14%

Physician Availability

The number of staff physicians admitting patients (STFPYN) to the hospital and the related measure of physician utilization of the hospital (BDXPYN) were too highly correlated with scale or other independent variables to yield meaningful results.

Average Length of Stay

The average length of stay (ALOS) was included in the regressions to account for differences in output among different classes of hospitals whose patients required different periods of care. Inclusion of the variable, which was significant in both total and average cost regressions including all hospital classes in the sample, did not affect output coefficients. However, the significance of the coefficients in the secondary and P3 classes indicate that some degree of heterogeneity of output associated with length of stay remains unaccounted for within these two classes.

The signs of estimated coefficients in the average cost regressions were as expected indicating that a longer length of stay, ceteris paribus, reduced the average cost per patient day by 3.1 percent and increased the average cost per stay by 10.6 percent. In the total cost regressions, however, the estimated sign is negative suggesting the perverse association of lower total costs and longer length of stay.

Homogeneity Adjustment Variables

Table 18 presents the regression results for the three alternative specifications: (1) without any facility adjustment variable, (2) with FACIL included, and (3) with dummy variables. Inclusion of either FACIL or the dummies resulted in a reduction of the estimated coefficients (b_0 or a_0) of the output variable. Reference to Table 18 compares the b_0's and the a_0's in the third column under each of the three assumptions for each of the dependent variables, LGTCHO, ACHPTD, and ACHSTA. Addition of either FACIL or the dummy substitutes reduced the values of b_0 and a_0. For example, in the case of LCTCHO, b_0 is reduced from 1.0757 to 0.9598 by including FACIL and to 0.9906 with the dummies. The level of significance of the output coefficients remains quite high with a minimum "t" statistic of 41.6.

The analysis above assumed that hospital classes account for different levels of cost curves. The possibility of a nonlinear relationship between costs and output within each class was investigated in an exploratory manner by including combinations of interaction variables defined as the products of output squared and respective dummy variables. In no instance did the interaction variables show promise of contributing additional explanatory power.

Capacity Utilization

The percent of total hospital beds which are occupied (OCRATE) is a measure of hospital capacity utilization.

TABLE 18

NUMBER OF FACILITIES ADJUSTMENT FOR PRODUCT HOMOGENEITY

ESTIMATED EQUATIONS[1] COMPARED FOR 3 CASES: (1) WITHOUT ADJUSTMENT, (2) WITH FACIL, (3) WITH DUMMIES, FOR 3 DEPENDENT VARIABLES (LGTCHO, ACHPTD, ACHSTA) TOTAL HOSPITAL COSTS, 1972-1974, N = 200

Dependent Variable	Constant C	Output b_0 or a_0	FACIL	F1	F2	F3	F4	R^2	$F_{(u,v)}$	Standard Error
LGTCHO	.5901 (0.7)	1.0757 (75.2)	-	-	-	-	-	.9815	(5,194) 2,064	.1608
LGTCHO	1.800 (2.4)	0.9597 (41.6)	0.019 (6.1)	-	-	-	-	.9845	(6,193) 2,049	.1475
LGTCHO	2.167 (2.7)	0.9906 (43.6)	-	-.3678 (-5.3)	-.2755 (-4.7)	-.2303 (-3.9)	-.1441 (-3.6)	.9840	(9,190) 1,300	.1512
ACHPTD	62.10 (5.7)	$.1543 \times 10^{-3}$ (4.9)	-	-	-	-	-	.5606	(5,194) 49.5	13.84
ACHPTD	47.06 (4.6)	$-.0953 \times 10^{-3}$ (2.0)	1.67 (6.5)	-	-	-	-	.640	(6,193 57.2	12.56
ACHPTD	84.41 (7.3)	$-.649 \times 10^{-5}$ (-.2)	-	-31.34 (-5.7)	-23.84 (-4.7)	-21.43 (-4.0)	-15.71 (-4.5)	.626	(9,190) 35.3	12.90
ACHSTA	-123.71 (-1.8)	0.131×10^{-2} (6.5)	-	-	-	-	-	.695	(5,194) 88.4	88.02
ACHSTA	-226.46 (-3.5)	$-.0395 \times 10^{-2}$ (-1.3)	11,410 (7.1)	-	-	-	-	.759	(6,193) 101	78.47
ACHSTA	37.21 (0.5)	$.2278 \times 10^{-3}$ (0.9)	-	-214 (-6.2)	-164 (-5.2)	-152 (-4.5)	-120 (-4.9)	.747	(9,190) 63.4	80.97

TABLE 18--Continued.

[1]Estimated Equations of Form:

$$\begin{matrix} \text{LGTCHO} \\ \text{ACHSTA} \\ \text{ACHPTD} \end{matrix} = C + b_0 \begin{matrix} \text{LOGPTD} \\ \text{PTDAYS} \\ \text{PTDAYS} \end{matrix} + \text{TIMEYR} + (\text{FACIL or F1+F2+F3+F4}) + \text{MITERT} + \text{ALOS}$$

$$+ \begin{matrix} \text{LGLHOS} \\ \text{ACLHOS} \\ \text{ACLHOS} \end{matrix}$$

Differences in observed occupancy rates of hospitals of different scales reflect in part long run adjustments to cost and demand conditions. Omission of this variable assumes that all hospitals are adjusted to long run conditions and are operating at optimum hospital capacity. Observed data, however, reflect short run deviations from the long run cost-output relationship. Thus, a hospital whose annual costs are reported for output levels below the optimum tends to overstate the unit costs of production. Comparison of unit costs with another hospital of the same scale but producing at greater than optimum levels could overstate estimates of scale economies.

Inclusion of the OCRATE in the regressions increased the magnitude of the output coefficients thereby increasing the degrees of estimated diseconomies of scale compared to the equations excluding OCRATE. Increases in estimated coefficients accounted for approximately three percent of average costs evaluated at mean output levels.

Mean values of occupancy rates ranged from a low of 0.597 for primary care institutions to 0.747 for secondary and to the high of .780 for tertiary care centers. The mean for the entire sample of 200 observations was 0.656 ranging from a low of 0.313 to a high of 0.920. Table 19 presents mean values and correlation coefficients of OCRATE with selected regression variables by hospital class.

TABLE 19

MEAN VALUES AND RANGES OF OCCUPANCY RATES AND CORRELATION COEFFICIENTS WITH SELECTED VARIABLES BY STRATIFIED SAMPLE, 1972-1974

Class & Sample	No. of Obser-vations	Correlation Coefficients of OCRATE with						OCRATE	
		LGTCHO	ACHPTD	LOGPTD	PTDAYS	MITERT	ALOS	Mean Value	Range
ALL HOSPITALS	200	.591	.129	.650	.540	-.449	.130	.656	.313-.920
TERTIARY CARE	23	.342	-.527	.497	.553	NA	.276	.780	.628-.886
SECONDARY CARE	51	.647	.408	.597	.604	-.494	-.210	.747	.590-.920
PRIMARY CARE	126	.207	-.404	.402	.372	-.197	.055	.597	.313-.860
P1	27	.171	-.325	.379	.376	-.175	.412	.587	.330-.880
P2	53	.489	-.453	.709	.645	-.133	-.007	.616	.313-.880
P3	42	-.100	-.509	.137	.063	-.480	.087	.588	.418-.734

Occupancy rate coefficients consistently have negative values and are significant except for the secondary care hospitals. Magnitudes of the coefficients indicate that the average hospitals could reduce average costs per patient day by 9.0 percent by increasing their average occupancy rate by one standard deviation from the mean of .656 to .793.

Returns to Scale in Dietary, Medical Records and Pharmacy Services

In each of the three hospital services, total and average cost functions were estimated using the same functional form and methodology as specified for aggregate hospital expenses. Only statistically significant variables displaying stable estimated coefficients over time were retained in estimated equations. As was expected each service and function exhibited different degrees of returns to scale. Table 20 presents the returns to scale parameter, r, and the respective range of output for which the total cost equations for each service and functions are estimated. The results of each service are discussed individually in the following sections.

Dietary Service

The estimated coefficients of the total and average cost functions indicate that dietary services are produced under conditions of declining costs over the entire range of output with a tendency for economies to increase slightly

TABLE 20

RETURNS TO SCALE PARAMETERS (r) AND RANGE OF OUTPUT, DIETARY, MEDICAL RECORDS AND PHARMACY SERVICES. DEPENDENT VARIABLES: LOGARITHMS OF TOTAL SERVICE COSTS

Service	Dependent Variable	Returns to Scale Parameter r	Output			Degrees of Freedom
			Variable Name	Range of Output	Mean Value	
Dietary	LGTCDI	1.220	Number of Meals	18,350 to 1,280,240	175,597	56
		1.019	(LGMEAL)	18,350 to 235,128	68,425	49
Medical Records	LGTCMR	1.010	Number of Discharges	670 to 23,624	5,297	63
		1.048	(LGDISC)	670 to 9,546	3,368	54
Pharmacy	LGTCPH	1.008	Number of Patient	3,000 to 200,000	34,434	65
		1.045	Days (LOGPTD)	3,000 to 100,000	20,733	56
Cost of Drugs	LGCDGS	1.010	Number of Patient	3,000 to 200,000	34,434	65
		1.068	Days (LOGPTD)	3,000 to 100,000	20,733	56

as scale increases in the range of the largest hospitals. Results from the pooled sample of 64 observations on 22 hospitals showed a coefficient of output (the annual number of meals served) of 0.896 (t=44.1) in the total cost function which is consistent with decreasing costs (r=1.116). Regression equations are summarized in Tables 21 and 22 for the dietary service. Smaller scales of the primary care hospitals did not exhibit as high degrees of economies of scale. In the sample of 55 observations, which excluded the three largest hospitals, the estimated output coefficient of 0.981 was not significantly different from unity indicating that constant returns to scale (r=1.019) describe production conditions in the range of the smaller hospitals.

Inclusion of dummy variables for the primary care class hospitals increased the degree of estimated economies of scale over the entire range of output. The linear output coefficient was reduced to 0.820 (r=1.220) after allowing for a lower level of production costs in primary care hospitals. The lower level is in part explained by a lower average cost of labor in primary care hospitals amounting to an average of $467 or 10.6 percent per year below the mean for all hospitals in the sample.

Estimated average cost equations shown in Table 22 yield results generally consistent with those of the total cost functions. Coefficients of dummy variables indicate declining cost levels occur within the primary care hospitals.

TABLE 21

SUMMARY OF TOTAL COST REGRESSION EQUATIONS: DIETARY SERVICE
DEPENDENT VARIABLE: LGTCDI, POOLED SAMPLES 1972-1974

Estimated Coefficients and (t-scores) for Each Independent Variable

Number Observations	Constant	LGMEAL	LGLDIE	CONTRL	TIMEYR	R^2	F(,)	S.E.	Primary Care Class P1 & P2	Primary Care Class P3
64	-.77 (-.7)	.896 (44.1)	.27 (1.8)	.13 (3.1)	.054 (2.2)	.98	(4,59) 700	.150	-	-
55[1]	-2.0 (-1.7)	.981 (29.7)	.31 (2.1)	.14 (3.2)	.050 (2.0)	.95	(4,50) 251	.145	-	-
64	-.24 (-.2)	.820 (27.6)	.33 (2.2)	.08 (1.9)	.052 (2.3)	.98	(6,57) 542	.139	-.2066 (-3.0)	-.2149 (-3.2)

[1]Sample omits largest 3 hospitals.

TABLE 22

SUMMARY OF REGRESSION EQUATIONS: DIETARY SERVICE
DEPENDENT VARIABLE: ACMEAL, POOLED SAMPLES 1972-1974

	Estimated Coefficients and (t-scores) for Each Independent Variable										
Number Obser-vations	Constant	MEALS (10^{-6})	MEAL2 (10^{-12})	ACLDIE (10^{-4})	CONTRL	TIMEYR	Primary Care Class P1 & P2	Primary Care Class P3	R^2	F(,)	Standard Error
64	1.151 (4.6)	-.7214 (-5.3)	-	.955 (1.6)	.167 (2.5)	.088 (2.3)	-.095 (1.0)	-.236 (-2.4)	.51	(6,57) 9.9	.234
55[1]	1.094 (3.8)	-2.582 (2.6)	-	1.79 (2.8)	.204 (3.0)	.074 (1.8)	-.276 (-2.3)	-.424 (-3.6)	.46	(6,48) 6.9	.227
64	1.208 (5.1)	-1.998 (-3.8)	.9729 (2.5)	1.300 (2.3)	.168 (2.7)	.078 (2.1)	-.219 (-2.3)	-.352 (-3.3)	.56	(7,56) 10.2	.223

[1] Sample omits largest 3 hospitals.

In each of the average cost regressions, class P3 hospitals experience lower costs per meal of between 13 and 14 cents. Exclusion of the largest hospitals decreases the output coefficients of the linear average cost equation from -0.7214 to -2.582 and indicates a more rapidly falling average cost curve with minimum average cost occurring at a scale of more than 2,000,000 meals per year which is twice the volume of the largest hospital considered in this study. The quadratic form of the total cost function consistently yielded expected signs but unstable coefficients.

The dietary service consists of approximately 53 percent labor input and 46 percent cost of food and supplies. The labor and food supply functions were examined by estimating total and average cost functions where dependent variables were wage costs and food-supply costs. The results of these regressions indicated that economies of scale in the dietary service are obtained primarily from labor activities. Increasing returns to scale in the total labor cost function (LGWCDI) were indicated by the estimated output coefficient of 0.796 (r=1.256). Food supply costs, however, exhibited constant returns to scale conditions over the range of output with a tendency for economies of scale to appear in the largest sized hospitals.

The variable CONTRL which represents ownership by county or municipal government was significant statistically in both dietary service and food supply cost functions but was not significant in the labor cost function. Contrary to predictions the positive sign of the coefficient of CONTRL indicated that hospitals owned by local government pay higher costs for dietary food and supplies than nongovernment owned hospitals. This cost differential amounted to approximately 18 cents per meal during the three year period or 11.1 percent of the mean cost of food and supplies.

The output elasticity of labor input estimated from the coefficient of the price of labor (LGLDIE) ranged between .30 and .40. Geographic variables did not contribute any explanatory power in the regressions. The effect of trend (TIMEYR) was to increase dietary costs by an average of eight percent per year.

Medical Records Service

Constant returns to scale describes the results of estimated equations for the medical records service. The estimated coefficient of output in the total cost regression including 70 observations was 0.990 (r=1.01). Output coefficients in the average cost regressions were not statistically significant with t scores of less than 0.2. Results are shown in Table 23. The possibility of slight economies of scale in the smaller range of output was suggested by the exclusion of the three largest hospitals. Over the shorter range of output, the returns to scale parameter increased to 1.048 in the sample of 61 observations.

TABLE 23

SUMMARY OF REGRESSION EQUATIONS: MEDICAL RECORDS SERVICE
DEPENDENT VARIABLES: LGTCMR AND ACMEDR, POOLED SAMPLES 1972-1974

		Estimated Coefficients and (t-Scores) for Each Independent Variable								
Dependent Variable	No. of Obser- vations	Constant	DISCHG LGDISC	MITERT	P4	MEMBER	INFLA	R^2	F(,)	Standard
ACMEDR	70	11.17 (15.4)	$.80\times10^{-5}$ (.2)	-.0459 (-6.0)	1.489 (3.1)	-.739 (-1.7)	1.45 (3.6)	.52	(5,64) 14	1.60
ACMEDR	61[1]	11.42 (15.0)	-1.9×10^{-5} (-.1)	-.0460 (5.7)	1.30 (1.6)	-.861 (-2.0)	1.28 (2.9)	.45	(5,55) 9.0	1.63
LGTCMR	70	2.52 (11.2)	.990 (37.6)	-.0055 (-7.7)	.192 (3.4)	-.098 (-2.1)	.157 (3.6)	.98	(5,64) 498	.174
LGTCMR	61[1]	2.76 (7.6)	.954 (18.6)	-.0050 (-5.1)	.202 (2.6)	-.11 (-2.3)	.147 (3.0)	.95	(5,55) 218	.180

[1]Sample omits largest 3 hospitals.

for cross sectional data shows declining magnitudes and levels of significance for each successive year from 1972. Apparently, lower cost levels experienced by member hospitals in 1972 deteriorated to insignificance by 1974. This may be explained by the introduction in November of 1973 of the new service microfilming of medical records by MPSI for its member hospitals.

Microfilming represents a different mode of record storage and retrieval which at the outset establishes higher levels of hospital cost for the purchase of microfilm printing equipment and supplies as well as higher costs for microfilming of the original medical and other records. In some instances, the cooperative assisted the hospital in converting to microfilming of records from the traditional storage system. In others the cooperative became a substitute for the previous microfilm processor which was either a commercial firm or an in-hospital production activity. Available data did not allow for assessment of any long term effects on cost of the microfilm service.

Pharmacy Service

Constant returns to scale characterize the production conditions of the pharmacy service although there is some indication that small scale hospitals experience moderate economies of scale. Table 24 presents the estimated equations. Coefficients of the output variable in the average cost equations were not statistically significant although

TABLE 24

SUMMARY OF REGRESSION EQUATIONS: PHARMACY SERVICE

DEPENDENT VARIABLES: AVERAGE COST PER PATIENT DAY (ACPHPD) AND LOGARITHMS OF TOTAL COSTS OF PHARMACY (LGTCPH), TOTAL LABOR COSTS (LGWCPH) AND OF TOTAL COST OF DRUGS (LGCDGS)

		Estimated Coefficients and (t-Scores) for Each Independent Variable					
Dependent Variable	Number Obser-vations	Constant	PTDAYS LOGPTD	ACLPHA LGLPHA	REGPHA	CONTRL	ACCRED
ACPHPD	72	1.77 (5.2)	$-.39 \times 10^{-6}$ (-.2)	$.95 \times 10^{-4}$ (5.5)	1.33 (6.7)	-.52 (3.3)	-.43 (2.0)
ACPHPD	63[1]	1.85 (5.2)	-7.77×10^{-6} (-1.2)	$.93 \times 10^{-4}$ (5.1)	1.43 (6.4)	-.57 (3.4)	-.43 (1.9)
LGTCPH	72	-.55 (-1.3)	.992 (29.3)	.186 (5.6)	.356 (5.3)	-.152 (3.4)	-.156 (-2.5)
LGTCPH	63[1]	-.20 (-.4)	.957 (16.9)	.182 (5.1)	.387 (4.8)	-.175 (-3.6)	-.153 (-2.4)
LGWCPH	72	-12.8 (-11.8)	.907 (10.5)	1.258 (14.1)	1.48 (8.2)	.253 (2.2)	.554 (3.4)
LGWCPH	63[1]	-11.9 (-8.0)	.742 (4.9)	1.301 (13.8)	1.63 (7.5)	.312 (2.4)	.600 (3.5)
LGCDGS	72	-.04 (.0)	.990 (26.2)	.122 (3.2)	.167 (2.2)	-.157 (-3.2)	-.184 (-2.7)
LGCDGS	63[1]	.48 (.8)	.936 (14.9)	.118 (3.0)	.214 (2.4)	-.181 (-3.3)	-.180 (-2.5)

[1]Excludes largest three hospitals.

TABLE 24--Continued.

Dependent Variable	Number Observations	Primary Care Class P2	TIMEYR	PARMBR	R^2	F(,)	Standard Error
ACPHPD	72	1.01 (5.4)	.113 (1.1)	.452 (2.3)	.68	(8,63) 16.7	.586
ACPHCD	63[1]	.98 (5.2)	.134 (1.3)	.388 (1.8)	.70	(8,54) 15.8	.592
LGTCPH	72	.236 (4.4)	.019 (.7)	.161 (2.8)	.98	(8,63) 372	.168
LGTCPH	63[1]	.234 (4.2)	.024 (.81)	.153 (2.4)	.96	(8,54) 190	.172
LGWCPH	72	.638 (4.5)	.064 (1.0)		.95	(8,63) 178	.454
LGWCPH	63[1]	.623 (4.2)	.071 (1.0)		.94	(8,54) 129	.470
LGCDGS	72	.209 (3.5)	.026 (.8)	.118 (1.8)	.97	(8,63) 251	.188
LGCDGS	63[1]	.202 (3.3)	.032 (.9)	.100 (1.4)	.95	(8,54) 117	.192

[1]Excludes three largest hospitals.

their estimated signs were negative. For example, in the sample of 63 observations excluding the largest hospitals, the t statistic of -1.2 is not sufficiently large to warrant the conclusion that the coefficient is different from zero although comparisons of cross sectional data yield stable values. Evaluation of the coefficient at the sample mean of 20,733 patient days per year indicates that output accounts for 4.4 percent of average pharmacy costs per patient day.

A similar situation is indicated by the total cost functions. In the larger sample of 72 observations which included a range of output from 3,000 to 200,000 patient days, the output coefficient was equal to 0.992 (r=1.008) In the smaller sample, this coefficient is reduced slightly to 0.957 (r=1.045) indicating slight economies of scale occur over the range of 3,000 to 100,000 patient days. However, the estimate differs from unity by less than one standard error (0.056) and cannot be accepted as statistically significant. Class dummies were not significant except for the P2 class of hospitals, which experienced substantially higher average pharmacy costs per patient day.

Regressions were run for the drug purchasing function using patient days as the measure of output and the costs of drugs as the dependent variable. Results, shown in Table 24 for total drug costs (LCDGS), are nearly identical with those reported for the total pharmacy service since these data represent approximately 80 percent of the costs of the pharmacy service.

Geographical location did not appear as a significant variable in any of the pharmacy regressions. However, ownership by county or municipal government was associated with between $0.52 and $0.57 lower level of cost per patient day while hospital accreditation accounted for a $0.43 per patient day lower cost level. Approximately one-third of the hospitals in both samples are owned by local government while nearly three-fourths are accredited.

The influence of accreditation and ownership differs in direction in the labor and drug functions. Although the net effect on pharmacy costs of both variables was negative, in labor services (LGWCPH) accreditation and ownership coefficients were significantly positive indicating that accredited hospitals owned by local government pay higher salaries than nonaccredited voluntary hospitals. In the cost of drugs function (LGCDGS), which accounts for nearly 80 percent of total pharmacy costs, signs of the two variables were negative as in the coefficients estimated for total pharmacy services.

The presence of a full-time registered pharmacist on the hospital staff indicated by the dummy variable REGPHA was highly significant statistically and substantial in magnitude. This variable accounted for additional per patient day cost of between $1.33 and $1.43. One-third of all the hospitals did not have full time staff pharmacists.

Factor Prices

The output elasticities of labor in the pharmacy service were estimated at .188 for the sample of 72 observations and .190 for the smaller sample. The drug price index, MPSIPR, was not included in final results because of the perverse sign of its coefficient. Although coefficients consistently had t scores in excess of two, the sign of the index was negative indicating that an inverse relation existed between total pharmacy cost and price.

Three factors may account for this unexpected sign: negative correlations between the price index and scale of -0.54 and total pharmacy costs of -.56; the lack of randomness in selection of the 53 drugs included in the index; and incomplete data sets.

Not all hospitals reported prices or usage of all drugs included in the sample. Missing data were replaced by mean values of reporting hospitals of a respective hospital size under the assumption that hospitals of similar size would pay comparable costs. Furthermore, because of non-reporting hospitals, the sample size was restricted to a maximum of 15 hospitals and 44 observations of pooled data.

Participation in Hospital Cooperative

Membership in the cooperative is expected to result in cost reductions to member hospitals in those services exhibiting declining costs over the range of scale of production of the individual hospitals. Because pharmacy services exhibited essentially constant returns to scale, or at best only moderate declining costs of less than four percent, membership in the pharmacy service is not expected to lower unit costs to member hospitals. To the contrary, membership would be expected to raise unit costs if the cooperative in any way duplicates functions continuing to be provided by each hospital or if the cooperative provides additional functions which alter the quality of the product. The effects of membership in the cooperative of this study reflect the net change in hospital operating expenses including economies associated with the larger scale of production of the cooperative and also including the additional costs of providing duplicated and new functions.

The additional function of repackaging drugs from bulk to unit doses which was not performed by any member or nonmember hospital requires the two related activities of storing and distributing drugs. Drug storage is to some extent duplicated by the cooperative in its warehousing function although the cooperative may enable hospital inventory levels to be reduced.

Pharmacy reports from member hospitals documented reductions both in the dollar value and the quantity of drug inventory levels in excess of 50 percent with an average reduction of 13.9 percent in dollar value. While most hospitals experienced reductions in relation to the degree of participation in the cooperative, some continued to report unchanged inventory levels even after several months of participation despite projected reductions based on initial feasibility studies. (EMR, 1976, p. 17) This indicates that while the cooperative may provide a potential for improved cost efficiency, such improvements may not be internalized by the hospital. In some cases continued activities by a hospital may be an attempt to evaluate the performance of the cooperative program such as in the price gathering activity of the purchasing function which continued within member hospitals despite negotiation of group contracts by the cooperative. This type of information activity may diminish as member institutions and personnel learn about and come to accept the cooperative as a responsible and efficient service organization.

Substantial price discounts obtained by cooperative purchasing were documented in the areas of drugs, intravenous products and other medical and hospital supplies. (Ibid., pp. 7-10, 44) To some extent group discounts reflect lower costs incurred by the vendor in marketing and distributing larger volumes. For those products which are warehoused the cooperative must absorb the costs of handling and distributing functions which the previous vendor no longer performs.

The results of estimating the effect of membership support a tentative conclusion that membership in the cooperative pharmacy service raised the average cost per patient day by approximately 14 percent above nonmember costs in 1973 and by 9.0 percent in 1974 while at the same time making available unit dose packaged drugs which were previously unavailable from commercial drug wholesalers or manufacturers. The effects of membership are indicated by the positive sign of the estimated coefficients of four alternative variables. Estimated coefficients and t statistics of these variables are shown in Table 25 for yearly and for pooled samples of 1972-1973, 1973-1974 and 1972-1974 data.

Membership was measured by two dummy variables, MEMBER and PARMBR. Membership at any time during 1972 through 1974 (MEMBER) did not differentiate the base line level of pharmacy unit costs for nonmember institutions, thereby supporting the conclusion that initial cost curves of member and nonmember pharmacies existing prior to the cooperative come from the same population. Hospital membership in a particular year (PARMBR), however, defined a higher level of both total and average costs. The coefficients of PARMBR of 0.236 (t=2.0) and 0.134 (t=1.7) in 1973 and 1974 respectively, estimated from the total cost equations, indicate that member hospitals experienced an upward shift in average pharmacy costs per patient day. The results of cross sectional samples which were limited in the number of degrees of freedom to 14 and 15, were also consistent with results of the pooled samples which had from 39 to 64 degrees of freedom.

TABLE 25

SUMMARY OF REGRESSION EQUATIONS: MEMBERSHIP AND PARTICIPATION VARIABLES
PHARMACY SERVICE, DEPENDENT VARIABLE: LGTCPH[1]

		Estimated Coefficients and (t-Scores) for Each Independent Variable				
YEARS	NUMBER OBSERVATIONS	MEMBER	PARMBR	PARMOS	PARWTD	PT2MOS
1972	23	-.012 (-.14)	--	--	--	--
1973	24	.046 (.4)	.236 (2.0)	.016 (1.0)	.036 (.75)	.00015 (1.1)
1974	25	.107 (1.4)	.134 (1.7)	.014 (2.3)	.017 (1.6)	.00014 (2.2)
72-73	47	.021 (.3)	.177 (2.10)	.013 (1.2)	.0356 (1.0)	.00011 (1.2)
73-74	49	.074 (1.2)	.178 (2.9)	.015 (2.6)	.019 (1.8)	.00014 (2.5)
72-74	72	.049 (1.0)	.161 (2.8)	.014 (2.6)	.020 (2.1)	.00013 (2.1)

[1]Estimated equations included variables shown in Table 24 for LGTCPH plus one of the above measures of membership of participation. TIMEYR was omitted from cross sectional samples.

The degree of participation of member hospitals was measured by two variables. The variable PARMOS is the number of months per year during which a hospital purchased pharmacy services from the cooperative while PARWTD is a weighted measure of participation calculated by multiplying the number of months of participation (PARMOS) times the proportion of a hospital's monthly pharmacy costs purchased from the cooperative. Both of these participation variables yield results similar to those of membership (PARMBR) although statistical significance is not as high.

The results shown in Table 25 for total cost equations including all reporting hospitals are also representative of the smaller samples which excluded the three largest hospitals.

Interaction variables were included to determine the combined effect of participation and increases of scale. Positive coefficients of the interaction variables for both linear and squared output (PTMOS or PT2MOS in total cost and PTAC or PT2AC in average cost functions) were estimated in total and average cost equations indicating that increases in scale of production and participation are also associated with higher levels of cost. To the extent that the hospital pharmacy services produce in the range of decreasing costs, the positive coefficient would indicate that the larger scale hospitals would benefit proportionately less than smaller scale hospitals. Failure to clearly establish the existence of a U-shaped or L-shaped average cost curve renders this conclusion highly tentative.

CHAPTER VI

CONCLUSIONS

This study is an empirical examination of the cost efficiency of multihospital arrangements as an alternative structure for organizing the production of hospital services. The thesis underlying multihospital arrangements is that hospitals could lower unit costs of production by internalizing technological efficiencies obtained by the hospital cooperative which specialized in production at larger scales. Economic theory, as presented in Chapter II, suggested two conditions must be met if the cooperative is to reduce hospital costs. First, the activity or process which the cooperative undertakes must be produced under conditions of substantial declining costs in the range of production by the autonomous hospitals. Secondly, the activity or process must be independent at the stage of production and therefore be separable from the hospital. If these two conditions are met, cooperative arrangements offer a method of cost reduction to hospitals that are unable to achieve economies of scale through expansion in their own scale of production of final output.

Previous cost studies, concerned with optimum scale of aggregate hospital production generally, conclude that minimum average costs are achieved at a hospital size of between 200 and 400 beds. Since three fourths of all United States hospitals are smaller than 200 beds, it would appear that most hospitals are operating on the declining portion of the long range average cost curve and would expand scale were it not for limited market demand. The existence of economies of scale at the aggregate level is tentative evidence that substantial economies exist in numerous functions and processes. Furthermore, the smaller scale hospitals would be expected to have relatively greater potential benefits from cooperative arrangements because of relatively greater potential economies associated with indivisibilities of factor inputs at smaller scales.

Hospitals considered in this study are in general similar to those of the nation. Hospital size, measured by the number of beds, ranged from a low of 19 to a high of 625 beds with an average of 130 beds. Less than 20 percent of the 68 hospitals included in this study were larger in size than 200 beds. However, a significantly greater proportion of hospitals in this study were located outside of metro areas compared to thirty three percent for all hospitals in the United States. Furthermore, none of the hospitals in this study was operated as a for-profit institution.

As in other empirical studies of hospital costs, the conclusions of this study must be interpreted in light of the weaknesses inherent in the assumptions of the methodology and in the data base. The foremost problem of hospital cost studies is the selection of an appropriate measure of output which is homogeneous across a broad range of scales of production. In this study, the aggregate output of the hospital, measured by the number of patient days, was assumed to be homogeneous within hospital classes.

Hospital classes were determined on the basis of the number of similar facilities and services provided. Within classes, however, the number of hospital facilities and services provided varied from a minimum of three in class P1 of primary care hospitals to a maximum of fourteen in the tertiary care class. Data limitations prevented classifying hospitals either by the same number of or by identical services. The effect of heterogeneity in the measure of output is to bias estimated returns to scale upwards thereby underestimating the degree of economies of scale.

In regressions of data including all hospital classes, differences among classes were assumed to be accounted for by different levels of cost measured by the intercept variable for each class. The statistical significance and substantial magnitudes of the dummy variables for each class gave convincing evidence that classes of hospitals providing broader product mixes experience higher levels of cost. The exception was the difference between the two primary care classes, P2 and P3, which are not significantly different in cost level as indicated by the magnitude of the dummy variables for class.

Estimates of returns to scale obtained from regressions for each class separately and combinations of classes indicated that diseconomies of scale describe production conditions for all classes of hospitals with the exceptions of the smallest primary care class and the largest class of tertiary care hospitals. In these two exceptions, estimated returns to scale indicate declining or constant cost conditions of production.

Tentative conclusions based on these results suggest that only hospitals producing the narrowest and the broadest product mixes experience constant or declining costs of production, while hospitals within the mid range produce subject to increasing cost conditions.

One explanation for diseconomies, advanced by Lee (undated monograph), is that hospitals expand their product mix by adding services which require expensive specialized factors of production which, however, are utilized at below optimum scales. Lee concludes that the basic problem is an excess of specialized inputs relative to common inputs and suggests that more efficient utilization of hospital resources could be achieved by reorganization of hospital output which would bring about reductions in the product mix of some hospitals while increasing specialization of output in the production of individual services. (Ibid., pp. 13-16) The distinctive feature of Lee's approach is the requirement for consideration of the demand for and supply of specific types of hospital care. Worthy of further consideration are also the questions of the substitutability of resource inputs into production of different services and the mix of services which approximates a joint product in production as distinct from independent services which are the primary candidates for specialization. These are areas in which further research is required and in which current data limitations are severe.

Differentials in wage costs also explain part of the differences in cost levels among classes of hospitals. Average wage compensation for hospitals in each class rose consistently from $5,135 per year in the smallest class, P1, to $6,528 per year in the tertiary care hospitals located in the urban areas. Differences in wage levels, which are expected if expansion of product mix occurs by adding services which require more expensive and more specialized labor inputs, are accounted for by the intercept variable for each class.

Geographic location appears to be inversely related to the level of hospital costs for aggregate product regardless of class or product mix. Of the four geographic variables tested, the number of miles between a hospital and the nearest tertiary care referral center (MITERT) was the most acceptable measure. In all classes except one the estimated coefficient of this variable was statistically significant with negative sign. In the smallest primary care hospital class the estimated coefficient was positive in sign but not statistically significant with a t score of 1.6.

The average distance for primary care hospitals was 77 miles ranging from zero to 180 miles, while the average for secondary care hospitals was 51 miles ranging from zero to 99 miles. While coefficients varied by class from 15 to 26 cents per mile, the average distance for all hospitals of 61 miles and of 15.8 cents per mile represents a difference of $9.64 per patient day or more than 11 percent of total hospitals costs per day. Based on these results it is concluded that rural location is associated with lower unit costs of aggregate hospital production.

One possible explanation for lower costs in more remote areas is that the location variable may reflect cost of living differentials between urban and rural areas. Cohen (1967) claims that such differentials tend to make rural institutions appear to be relatively more efficient compared to hospitals located in urban areas. If these differentials exist permanently and are not merely temporary lags behind urban wage and salary levels, planning for hospital construction services should include the influence of location on operating costs. Further research in this area could prove fruitful.

Other factors not considered in this study may also explain differences in costs associated with geographic location.

For example, total operating expenses of older facilities or of hospitals which received subsidies such as Hill-Burton construction funds may enjoy lower depreciation expenses than hospitals constructed in recent years at higher construction and financing costs.

Data limitations were also constraints. Cost data at the disaggregate level omit allocations of certain overhead items such as charges for space and equipment depreciation. In addition, fringe benefits were excluded from wages and salaries. Furthermore, except where physicians are salaried employees of the hospital, the input of physicians as factors of production were excluded. Attempts to account for the influence of physicians by including variables for physician availability and utilization of hospital facilities were inconclusive because of collinearity problems and because of the difficulty of defining homogeneous measures of physicians in rural and urban areas.

The double logarithmic total cost functions derived from a Cobb-Douglass production function were estimated under several restrictive assumptions. For example, factor prices and output were assumed to be exogeneously determined. Prices of labor inputs are fixed in the short run and appear to be competitively determined in the long run. Output is presumed to be exogenous since the individual hospital is morally, and sometimes legally, bound to provide care to all patients without regard to ability to pay. Administrators are assumed to behave rationally to minimize costs within their sphere of influence. The dual role of physicians who may influence demand for hospital care as agents for their patients and also influence the supply of services by their role as decision makers as members of the hospital board or medical staff is not considered. Finally, hospital product prices are assumed to be determined by regulatory agencies in the short run, however, the regulated hospital which is able to exert control over product prices in the long run renders this assumption less reasonable.

An examination of individual services and functions within the hospital reduces the degree of difficulty in selecting appropriate measures of output and also provides tentative evidence in regard to the potential for cost reduction by hospital cooperatives. A potential for cost reduction is indicated if substantial economies of scale exist in one or more hospital services or functions. In this study of three services, dietary, medical records and pharmacy, none is an independent service which could be completely separated from an acute care hospital. However, there exist functions within each of the services which are independent at stages of production prior to final consumption of the service product by the patient. Examples of separable activities performed by MPSI are microfilming of medical records, purchasing of drugs, repackaging of drugs from bulk to unit dose containers, and certain elements of warehousing and distributing products. These functions and activities may exhibit increasing or decreasing returns to scale independently of returns to scale for the entire service. Therefore, estimation of constant or decreasing returns to scale for each service does not deny the possibility of potential areas of cost reductions from cooperatives engaged in activities included in the overall service. However, estimation of decreasing costs for the service provides substantial evidence of potential for cost reduction under the condition that the source of declining costs lies within a separable function which also exhibits increasing returns to scale.

Advantages of cooperative arrangements such as group purchasing of food and dietary equipment and the employment of shared registered dietitians for the smaller hospitals are indicated as potentially beneficial in view of the estimated declining average cost curves for the dietary service. However, the primary source of these economies was traced to labor services while evidence of economies in food and equipment costs was present only at scales of the largest hospitals producing above 235,000 meals per year. For smaller hospitals, typically those offering only primary care, constant returns to scale were indicated. The primary care classes P1 through P3 experienced a lower level of costs attributed primarily to a ten percent lower average wage cost in these classes. Evidence also suggested that hospitals owned by local government pay approximately 11 percent higher costs for food and supplies than voluntary hospitals while no differential was found in labor costs associated with ownership. Geographic variables such as miles to the nearest tertiary care medical center did not explain variations in dietary costs.

The absence of declining average costs of production in the medical records department leaves unsupported the conclusion that cooperative arrangements will improve cost efficiency. In the area of microfilming of medical records, the results were also inconclusive. Although member hospitals utilizing the cooperative microfilming service experienced increased costs of production, available data did not allow for consideration of the initial cost increases associated with the changeover to the different methods of record storage and retrieval nor did data enable estimation of returns to scale in the microfilming function. Elsewhere (CEMR, 1976, p. 44) evidence of decreasing average costs has been reported, suggesting that delegation of this function to an auxiliary firm may be a more efficient mode of production although the scale possible for the cooperative may not be sufficiently large to successfully compete with for-profit firms specializing in the microfilming of hospital records.

The geographic location variable, MITERT, was highly significant in all equations estimated for medical records cost functions. Distance accounted for an average of 4.6 cents per mile which represents a lower cost of 30 cents or approximately four percent of average cost per discharge for the hospital located 66 miles from a tertiary care center.

Constant returns to scale were found over all ranges of output in the pharmacy service with some evidence of modest economies of scale in the range of primary care hospitals. In pharmacy service, labor inputs represent approximately 20 percent of total costs with the remainder attributed to the cost of drugs. Results of the labor cost regressions in pharmacy indicate moderately declining costs over the entire range of output with substantially greater scale economies existing in the smaller hospitals operating at scales from 3,000 to 100,000 patient days per year. Results, however, for the cost of drugs function, excluding labor costs, were almost identical with those of the total pharmacy service regressions. Slightly greater economies of scale were indicated in the range of smaller hospitals of less than 100,000 patient days per year although statistically significant differences could not be established.

Location was not found to be statistically significant in any of the pharmacy regressions. In contrast, ownership by county or municipal government was associated with a 15 percent lower pharmacy cost per patient day and accredited hospitals enjoyed nearly 12 percent lower costs per patient day while neither of these factors influenced the production costs of medical records or dietary services. Although the net effect on pharmacy costs of both variables was negative, results of regressions of pharmacy labor costs indicated that accredited hospitals owned by local government pay higher salaries than nonaccredited voluntary hospitals. The negative relationship between drug costs and ownership by local government provides tentative evidence to support the hypothesis that the purchasing of drugs on the state negotiated group contract lowers unit drug costs.

One of the chief differences between the very small and the larger hospitals is the availability of full-time professionals in special services such as medical records, pharmacy and dietary departments. In the small hospitals, the services of these professionals is often obtained on a part time consultant basis. For example, one third of all hospitals in this study employed part-time registered pharmacists whereas full-time registered professional dietitians and registered medical records administrators were usually not found except in secondary and tertiary care hospitals.[1] In pharmacy, the presence of a full time registered pharmacist on the hospital staff was associated with a higher per patient day cost of between $1.33 and $1.43, representing the substantial difference of 38 percent above the average pharmacy cost per patient day of $3.67.

Although the full-time equivalents and salary costs of part-time professionals were included in the study, an

[1]Minimum availability of registered professionals is required by accrediting and reimbursement agencies in some cases, such as one day per month for a registered dietitian.

unknown quantity of services, normally provided by these professionals in larger hospitals, may have been provided by other hospital personnel, such as nurses whose wage and time costs were not included in cost data. The effect of this omission would be to understate the unit costs of output in the smaller hospitals and therefore underestimate the degree of returns to scale in the respective range of output and overstate the difference attributed to the presence of registered professionals.

Estimated coefficients of membership variables in the estimated pharmacy cost functions support the tentative conclusion that membership raised the average cost per patient day of member hospitals by approximately 14 percent above nonmember costs in 1973 and by 9 percent in 1974. The increase in cost associated with membership in the cooperative reflects the difference in quality of product between members and nonmembers since the cooperative distributes a full line of unit dose packaged drugs to its members which are not available to nonmembers.

Repackaging drugs from bulk to unit dose containers is a function not performed by the majority of individual hospitals because of substantial costs of repackaging and because of requirements for greater storage space. (CEMR, 1976, unpublished data) The introduction of the unit-of-use drug distribution systems within the hospital requires a full inventory of unit dose packaged drugs all of which are not available commercially from drug manufacturers. The cooperative provides the repackaging function as well as the related functions of group purchasing, warehousing and distributing of a full inventory of unit dose packaged oral solids. While the net effect of the cooperative's services has been to increase unit costs, the amount of cost increase associated with membership in the pharmacy must be weighed against the improved quality of the unit-of-use drug distribution system which previously was unavailable to any of the member hospitals.

Evidence to support the hypothesis that smaller hospitals obtain relatively greater benefits from cooperative arrangements than larger hospitals was not supported by sufficiently high levels of confidence although the smaller member hospitals experienced slightly lower cost increases than did larger member hospitals. Other evidence, however, supports this contention. Participation in the pharmacy and other cooperative services was greatest by the smaller and rural hospitals. Further, documented records in one large urban hospital indicated that the purchasing of drugs from the cooperative was standard policy as long as the f.o.b. price was equal to or below that of alternative sources of unit dose drugs or if unit dose was otherwise unavailable, the hospital would pay a premium to the cooperative of 5 percent for unit dose drugs. This large hospital purchased 32 percent of its drugs from the cooperative in 1974

(CEMR, 1976, unpublished data) as compared to nearly 100 percent of drug costs by the smallest five hospitals.

Within the hospital industry today there is a growing belief that multihospital organizations offer substantial cost containment opportunities to individual hospitals. Because of the lack of research in this area which either points toward the economically feasible activities in which cooperatives will be successful or assess actual performance of existing cooperative arrangements, additional research is strongly recommended. Estimation of cost curves following the methodology of this study is one approach which can indicate the feasibility and assess the performance of multihospital arrangements in providing various activities and functions within the hospital and within services in the hospital. This approach, however, considers cost as the single criterion while ignoring other important considerations.

Already mentioned is the possibility of improving quality of services through cooperative arrangements thereby necessitating the examination of the benefit-cost trade offs. Another issue not considered in this study but which is important, especially to the future of smaller hospitals, is managerial efficiency. The related issue of the relative efficiency of nonprofit or for-profit ownership was not addressed in this study since none of the few proprietary hospitals located in Oklahoma is a member of MPSI. In other parts of the country, however, for-profit hospitals more frequently engage in multihospital arrangements than do non-profit hospitals.

The influence of geographic location deserves more attention in view of the findings of this study that indicate lower unit costs of production in rural hospitals. Furthermore, the influence on costs of resource scarcity within rural areas should be explored. The results of this study suggest that utilization of specialized factors of production, especially health professionals, is greater in rural than in urban areas. This may in part be explained by the sharing of specialized inputs or contracting for services on a part-time basis. Furthermore, smaller rural hospitals may exclude more specialized and relatively more costly services from their product mix.

Further research is necessary to determine how common and specialized factors of production are combined in production and to determine which hospital products should be considered as joint products essential to the minimum scope of services of small rural hospitals and which products are separable and thereby potential candidates for specialization in fewer but larger institutions. Analysis of independent services and functions should be extended to include a much broader number of organizational alternatives such as purchasing, contracting or consolidating activities.

Lower labor costs in rural areas and an apparently more efficient utilization of specialized inputs may explain why rural hospitals experience lower levels of costs. Planning for hospital services by regulatory agencies should consider these factors as well as the private costs of travel to the hospital incurred by patients, families and hospital employees. These findings suggest that rural hospitals may be efficient alternatives to the proposals for consolidation of hospitals into fewer numbers of larger more specialized institutions.

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APPENDIX A

METROPOLITAN VERSUS NON-METROPOLITAN AREAS AND POPULATION ESTIMATES

There is no single accepted definition for metropolitan or non-metropolitan areas. Estimates for the following definitions are reported from official sources.*

		Oklahoma Population	Percentage
A. Urban vs Rural; 1970 census data. Urban means a community (town, city) of 2,500 or more population.			
	URBAN:	1,740,137	68%
	RURAL:	819,092	32%
B. Inside Urbanized areas (census designation considers rural pop. of SMSA's counties as outside urbanized areas.) 1970 census data.			
	INSIDE URBANIZED AREAS:	1,049,072	41%
	OUTSIDE URBANIZED AREAS:	1,510,157	59%
C. Metropolitan areas of 10,000 or more population. (include 29 cities)			
1. 1970 census data			
	METRO:	1,371,572	54%
	NON-METRO:	1,187,657	46%
2. 1973 estimates from census data.			
	METRO:	1,455,495	55%
	NON-METRO:	1,177,505	45%
D. Metro areas of 20,000 or more population.			
1. 1970 census data (includes 15 cities			
	METRO:	1,162,711	45%
	NON-METRO:	1,396,518	55%
2. 1973 estimates from census data. (includes 18 cities)			
	METRO:	1,290,400	49%
	NON-METRO:	1,342,600	51%

*Source: 1970 Census, Bureau of the Census; 1973 Estimates from Oklahoma Employment Security Commission.

APPENDIX B

HOSPITAL MEMBERSHIP AND VALUE OF SALES BY SERVICE

Membership Category	Number Hospitals Using Service July 1975	Sales to Member Hospitals By MPSI Dec 72 - April 75
Full Membership	23	•
I.V. purchasing	23	$1,030,000
Drug purchasing	23	2,468,000
Consultant Pharmacy	5	13,000
Microfilming	15	38,000
Continuing Ed. Service	16	140,000
Educational Membership Cont. Ed. Service Only	6	Included Above
Microfilming Only	1	Included Above
Total Membership	30[1]	$3,689,000

[1]Column does not total because of multiple entries.

APPENDIX C

NATIONAL HEALTH PRIORITIES OF THE HEALTH RESOURCES PLANNING AND DEVELOPMENT ACT OF 1974

1. The provision of primary care services for medically underserved populations, especially those which are located in rural or economically depressed areas.

2. The development of multi-institutional systems for coordination or consolidation of institutional health services (including obstetric, pediatric, emergency medical, intensive and coronary care, and radiation therapy services).

3. The development of medical group practices (especially those whose services are appropriately coordinated or integrated with institutional health services), health maintenance organizations, and other organized systems for the provision of health care.

4. The development of multi-institutional arrangements for the sharing of support services necessary to all health service institutions.

5. The development by health service institutions of the capacity to provide various levels of care (including intensive care, acute general care, and extended care) on a geographically integrated basis.

6. The adoption of uniform cost accounting, simplified reimbursement, and utilization reporting systems and improved management procedures for health service institutions.

Source: 93rd Congress, S. 2994, Section 1502, January 4, 1975.

APPENDIX D

GROWTH OF MPSI: DECEMBER 1972-APRIL 1975

NUMBER OF HOSPITALS, NUMBER OF LICENSED BEDS AND PATIENT DAYS AND SALES VOLUMES OF MAJOR SERVICES

Date	Number of Hospitals	Number of Beds	Average Number of Patient Days per Month	Monthly Sales Volumes ($000's)				Total
				IV's	Drugs	CEC	Micro-film	
12/72	2	281	2.180	$ 3.9				$ 4.0
1/73	5	523	4,086	10.6				10.6
2	5	523	4,086	6.7				6.7
3	6	630	4,863	7.1	$ 0.8			7.9
4	7	1171	9,120	6.8	3.2			9.9
5	10	1624	13,166	7.4	13.1			20.5
6	10	1624	13,166	7.6	14.4	$ 5.9		29.0
7	11	1650	13,273	12.3	25.8	5.1		43.3
8	12	2260	19,061	25.1	35.3	5.9		66.4
9	13	2298	19,091	8.6	37.4	5.9		52.0
10	13	"	"	30.7	46.7	6.3		91.3
11	13	"	"	26.5	50.5	6.0	$ 0.3	84.0
12	13	"	"	29.7	49.1	5.2	0.3	87.0
1/74	13	"	"	27.4	61.1	5.8	.7	100.8
2	13	"	"	29.6	55.4	5.4	.3	90.7
3	13	"	"	34.9	53.8	6.4	1.1	122.4
4	13	"	"	57.4	63.8	5.5	1.1	134.8
5	13	"	"	38.2	65.8	4.9	1.1	126.1
6	14	2395	19,842	37.7	59.2	6.6	2.1	119.8
7	15	2449	20,142	43.6	74.6	5.4	1.8	139.6
8	15	"	"	49.7	60.4	5.9	2.6	127.1
9	15	"	"	54.8	66.6	6.6	3.8	129.3
10	15	"	"	38.4	68.9	5.9	4.3	118.2
11	16	2473	21,055	54.6	71.3	5.7	2.9	135.6
12	18	2852	25,127	68.6	69.5	6.8	2.3	152.1
1/75	19	3063	27,064	56.4	97.7	6.2	3.1	164.9
2	19	"	"	72.8	94.5	7.8	3.3	180.7
3	21	3123	27,600	80.7	95.1	7.5	3.8	193.1
4	21	"	"	71.8	93.9	6.9	3.7	181.2

IV's--intra[illegible] produ[illegible] CEC-- [illegible]